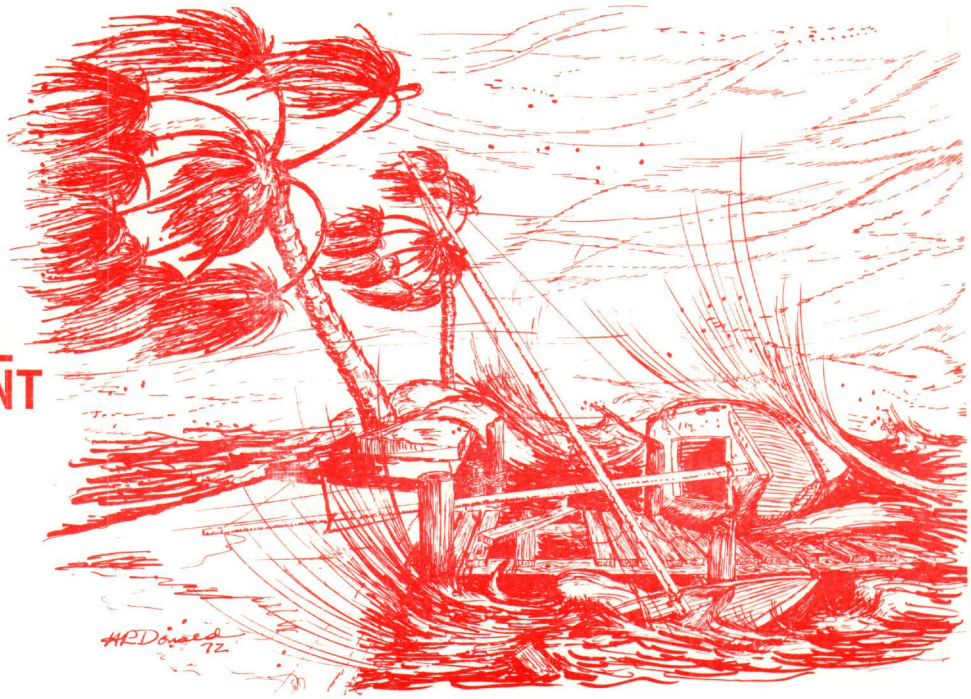
LOWER SOUTHEAST FLORIDA HURRICANE EVACUATION STUDY



TECHNICAL ASSESSMENT

BROWARD COUNTY

CORPS OF ENGINEERS
FEDERAL EMERGENCY MANAGEMENT AGENCY
NOAA NATIONAL HURRICANE CENTER
FLORIDA DEPARTMENT OF COMMUNITY AFFAIRS

LOWER SOUTHEAST FLORIDA
HURRICANE EVACUATION STUDY

TECHNICAL ASSESSMENT

A SUMMARY FOR BROWARD COUNTY

PREPARED FOR:
BROWARD COUNTY
EMERGENCY PREPAREDNESS DIVISION

PREPARED BY:
CORPS OF ENGINEERS
FEDERAL EMERGENCY MANAGEMENT AGENCY
NOAA NATIONAL HURRICANE CENTER
FLORIDA DEPARTMENT OF COMMUNITY AFFAIRS

FEBRUARY 1991

LOWER SOUTHEAST FLORIDA
HURRICANE EVACUATION STUDY
BROWARD COUNTY

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CHAPTER ONE
INTRODUCTION

GENERAL

The threat of a hurricane is real. The destructive potential of hurricanes poses a serious threat to the eastern and gulf coast areas of the United States during the summer and fall months. People seeking new life-styles continue to move to areas vulnerable to the effects of hurricanes. This desire to live in the coastal regions has caused an accelerated rate of growth and development in vulnerable areas.

One of the most hurricane vulnerable areas of the United States is the lower southeast coast of Florida. This area is comprised of Monroe County (the Florida Keys) and the mainland counties of Dade, Broward and Palm Beach. Historically, there have been many hurricanes which have affected this region, either directly or indirectly. This technical report is for the Broward County portion of the study area. The tracks of the primary storms affecting Broward County are shown on Figure 2-3 ,Chapter Two, Hazard Analysis.

PURPOSE

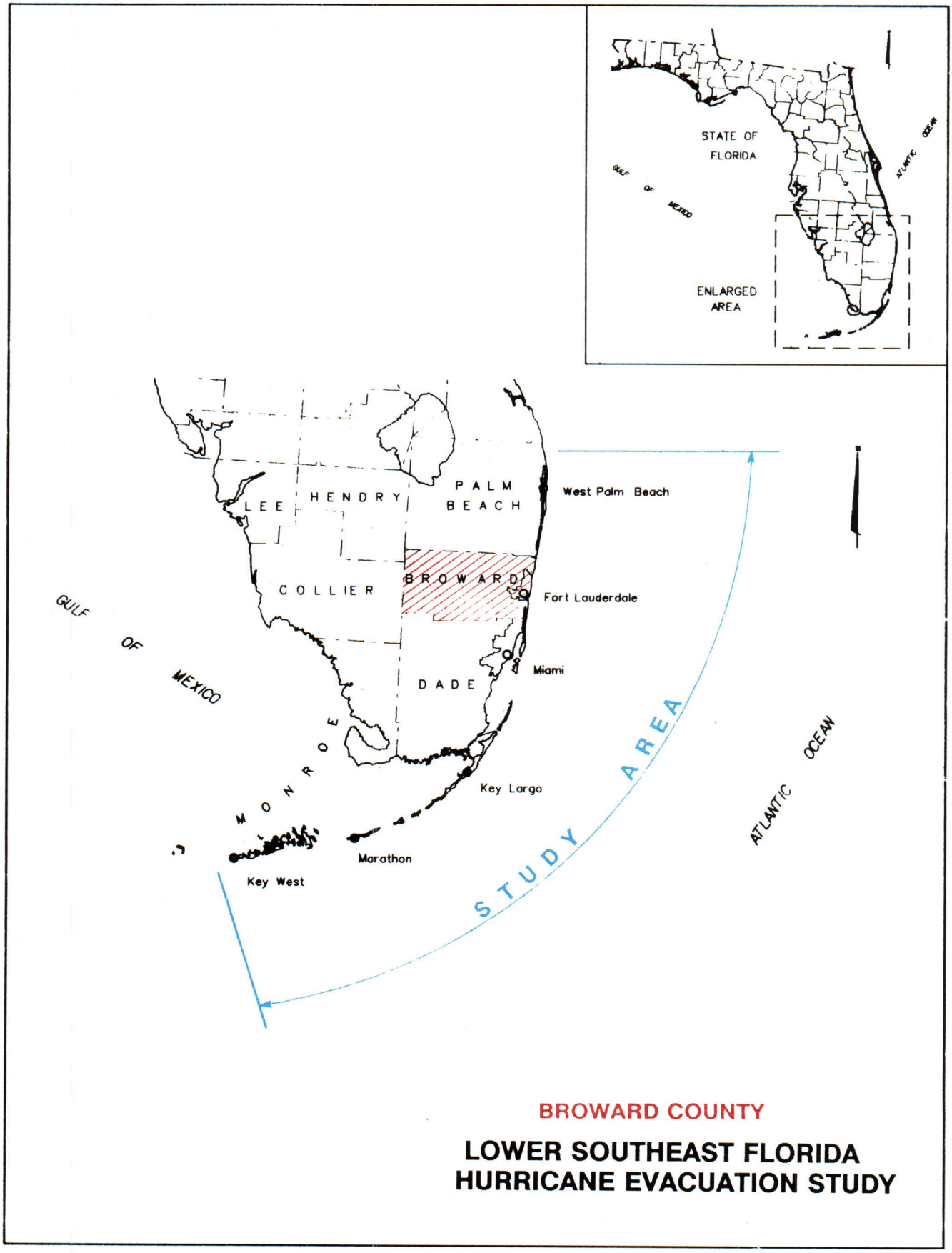
The Lower Southeast Florida Hurricane Evacuation Study is an update of the 1983 regional study for Monroe, Dade, Broward, and Palm Beach counties and is intended to provide emergency management officials with detailed data quantifying the major factors involved in hurricane evacuation decision making. The study area is shown on Figure 1-1. This update utilized the information from the SLOSH (Sea, Lake, Overland Surges from Hurricanes) models for Biscayne Bay and Florida Bay developed by the National Hurricane Center (NHC), National Oceanic and Atmospheric Administration (NOAA). The Biscayne Bay SLOSH model was appropriate to Broward County. These models were not available when the original study was completed. This fact, coupled with the tremendous development and population growth of the region, necessitated the current work. The primary emphasis of this study was the identification of life-threatening flooding resulting from hurricanes and the safe evacuation of populations from unsafe areas and conditions within the region.

AUTHORITY

The study authority for the Corps of Engineers is Section 206 of the Flood Control Act of 1960 (Public Law 86-645), and study authority for the Federal Emergency Management Agency is the Disaster Relief Act of 1974 (Public Law 93-288). These laws authorize the allocation of resources for planning activities related to hurricane preparedness. Authority for State of Florida involvement in the study is established by State Emergency Management Act, Chapter 252 (Sections 252.31 through 252.60), Florida Statutes (F.S.).

FUNDING

The Lower Southeast Florida Hurricane Evacuation Study was funded by the Federal Emergency Management Agency, the U. S. Army Corps of Engineers, and the State of Florida Department of Community Affairs. Local officials and agencies provided their input without direct charge to the study funds.



BROWARD COUNTY

LOWER SOUTHEAST FLORIDA HURRICANE EVACUATION STUDY

FIGURE 1-1

GUIDELINES

This study was conducted in accordance with the Corps of Engineers' publication, Technical Guidelines for Hurricane Evacuation Studies, November 1984, and the Federal Emergency Management Agency's publication, CPG-16, A Guide to Hurricane Preparedness Planning for State and Local Officials, December 1984.

STUDY PARTICIPANTS

The Lower Southeast Florida Hurricane Evacuation Study was a joint effort by the Federal Emergency Management Agency (FEMA); the National Oceanic and Atmospheric Administration (NOAA); the U. S. Army Corps of Engineers (Corps); the State of Florida, Department of Community Affairs (DCA) and the Emergency Management directors of Monroe, Dade, Broward and Palm Beach counties. Development of the technical data for the study was coordinated and documented by the Jacksonville District, Corps of Engineers, in conjunction with the various Federal and State agencies and local officials in the study area.

COORDINATION

In late 1987, in response to local concerns, FEMA and DCA requested the Corps to undertake an update for Lower Southeast Florida. The original study had been completed by the Corps in 1983, but local interests had expressed concerns about the rate of population growth occurring in the region and the applicability of the original study results. Specifically noted, were the numerous changes in arterial and major highways that would be used as evacuation routes. In addition, the old SPLASH hurricane model was used in the original study.

a. Study Management. The Jacksonville District, Corps of Engineers had responsibility for coordinating study efforts. Direction for this study was provided by an executive committee.

b. Executive Committee. An "ad hoc" Executive Committee consisted of key members of the Corps of Engineers, the Federal Emergency Management Agency, the State of Florida Department of Community Affairs, and the National Oceanic and Atmospheric Administration. Most of the members had extensive prior experience in conducting hurricane evacuation studies and actual hurricane response situations. The Executive Committee or appropriate representatives met on numerous occasions with the individual county emergency management directors to review the progress of the study, discuss and plan for future study tasks, and to insure that proper interagency and interjurisdictional coordination was accomplished.

DESCRIPTION OF STUDY AREA

a. Geography. The entire study area includes 300-miles of coastline with numerous islands and barrier islands, many of which are densely populated. Broward County is no exception consisting of considerable development on the ocean, on the barriers, and in and around the intracoastal waterway.

The western interior of Broward County also is heavily developed. Urban development in the western part of the county is rapidly merging previously individual communities into a single giant metropolitan area. This urban sprawl, moving rapidly westward, will have a significant impact on evacuation scenarios developed for the region.

b. Population. The 1980 Census of Population recorded a total population of about 3,300,000 people in the four county area with about 1,000,000 in Broward County. University of Florida demographic estimates indicate that the area's 1990 population will surpass 4,000,000 people. Table 1-1 shows the population by county for the years 1970 through 1990.

Table 1-1

County	1970	1980	1990*
Dade	1,267,792	1,625,979	1,900,000
Broward	620,100	1,014,043	1,250,000
Palm Beach	348,993	573,125	900,000
TOTAL	2,236,885	3,213,147	4,050,000

*Assumed Base Year Population. Taken from the University of Florida population projections.

There continues to be a very large population of senior citizens, many of whom have special needs, which require additional efforts in the event of an evacuation.

STUDY COMPONENTS

The Lower Southeast Florida Hurricane Evacuation Study consists of several inter-related analyses that develop technical data concerning hurricane hazards, vulnerability of the population, public response to evacuation advisories, time needed to complete evacuation, shelter needs, transportation routes, evacuation zones and decision strategies. The analyses are summarized in this Technical Assessment and task details are contained in separate appendices. The six major analyses comprising this evacuation study and a brief description of each are as follows:

a. Hazards Analysis. The Hazards Analysis identifies and describes the hazards caused by potential hurricanes. The analysis describes the level of threat from storm surge and wind that may be produced by hurricanes of various intensity as described by the Saffir/Simpson Hurricane Scale. The Sea, lake, and Overland Surges from Hurricanes (SLOSH) model was the primary tool used for the development of the surge and wind data. SLOSH model results showing the maximum of maximum envelopes of water (MOMs) are used as input data to determine land areas expected to be inundated under the different category hurricanes. The storm surge MOMs produced for each category of hurricane are displayed as water elevations above mean sea level(MSL). The delineation of land areas, including potential evacuation routes, affected by each category of hurricane is a major part of the hazard analysis. The second part of the hazard analysis consists of

estimating the time of arrival of gale force winds and storm surge elevations at pre-selected time/history points. These data are considered, along with advisories, in the process for determining when populated areas expected to be inundated should have their evacuation process finished.

b. Vulnerability Analysis. The Vulnerability Analysis provides a detailed identification of the areas and population vulnerable to specific hurricane threats. This analysis identifies the areas in each county affected by particular hurricane intensities, the population at-risk, potential exposure of medical facilities and other institutions to storm surge, and the time period before hurricane eye landfall when high winds or rising waters would make evacuations dangerous or impossible. Evacuation zones were developed for each of the risk counties. These zones were used to develop evacuation scenarios. A scenario is a group of adjacent evacuation zones that will be threatened by the storm surge from a specific hurricane intensity category. The vulnerability analysis began with a review of established evacuation zones in each county and municipal government area as compared with inundation areas identified in the hazards analysis. Working in conjunction with local emergency management directors and other concerned local government representatives, the existing data were revised and modified to reflect the newly developed data. The planning needs of local officials were considered critical, and all revisions were approved by those officials before being included in the study effort.

c. Behavioral Analysis. The Behavioral Analysis provided quantitative information on how the public can be expected to respond to a hurricane event within each county. The analysis developed locally usable information on the following: (1) the number of people who will evacuate; (2) the number of evacuees who will require transportation assistance; (3) the number of private vehicles that will be used during an evacuation; (4) the number of people who leave or attempt to leave the local area; (5) the number of people who will seek refuge in public shelters; (6) and when people in threatened areas would leave in response to forecast storm conditions, evacuation information or order, or local residential conditions (mobile home, structurally questionable home, seasonal or temporary residence, etc.). Several scenarios incorporating the above parameters were developed to reflect early (quick), average (median), and late (slow) responses to an evacuation order.

The methodology employed to develop this data consisted of telephone sample surveys and personal interviews within the study area; and data from other hurricane evacuation studies and from post-hurricane evacuation studies.

d. Shelter Analysis. The Shelter Analysis provided a county by county inventory of existing public shelter facilities, capacities of the shelters, vulnerability of shelters to both storm surge flooding and rainfall flooding, and identified the range of potential shelter demand for each county. Inventories of existing shelters were provided by the emergency management directors of the individual counties in conjunction with the American Red Cross. Potential shelter demands for ranges of hurricane threats were developed using data from the Behavioral Analysis.

e. Transportation Analysis. The Transportation Analysis utilized all of the above mentioned analyses to complete a reevaluation of the required clearance

times. Clearance time is the time required to move evacuees along the roadways from their residences to places of safety. This was accomplished for a number of situations or scenarios. Because this report is an update, the transportation analysis required depiction of necessary changes to evacuation route networks used in the participating counties. New bridges, roads, and the current state of projected roadway improvements (which are massive and on-going in the study area) were included in this analysis.

f. Decision Information. Decision arcs were constructed with Ft. Lauderdale as a center and tables were constructed to relate clearance times to distances from Ft. Lauderdale. Utilizing the appropriate storm speed each decision arc then defined the needed clearance time. These arcs will then be used with real time data from the NOAA marine advisories defining the extent of tropical force winds in miles from the storm center. A computer model called HURREVAC was developed for Broward County to enable the emergency management officials to automatically determine their decision thresholds utilizing the study generated data and the NOAA marine advisories.

STORM SURGE ATLAS

A Storm Surge Atlas for Broward County was financed by the State of Florida Department of Community Affairs. This effort was undertaken by contract and completed in January 1990. This document was published separate from the study components and Technical Assessment and delineates pictorially the storm surge inundation associated with the various categories of hurricanes. It also identifies the related storm surge elevations above MSL for each of those categories at selected locations.

CHAPTER TWO
HAZARD ANALYSIS

GENERAL

Hazard analyses for Broward County were developed by the National Hurricane Center at Coral Gables, utilizing the SLOSH Model. Biscayne Bay SLOSH Model data and historical information combined are very accurate in identifying the risks. However, the ultimate direction of approach of the storm, its impact area, and its intensity when it strikes are much more elusive in definition. The major threats generally stay in warm waters, have characteristic abrupt changes of direction and maintain inconsistent probabilities of land fall even within 12 hours of landfall. With such uncertainties, Broward County poses a very serious risk.

The summary tables and grid results depict the worst case situation for each category storm utilizing the maximum of maximums (MOMs) for any heading or track. Figures 2-1 and 2-2 depict the grid and selected headings and tracks for the SLOSH analysis. The two headings shown are the two most likely ones for the county. Remaining headings and tracks are included in the Hazards Appendix. Historical storms are shown on Figure 2-3. A SLOSH atlas was prepared for Broward County and was completed in January 1990. Since that effort was done separately from this data assembly, there may be some minor variations in the data presented here and displayed on the atlas maps. Any differences would be inconsequential to the basic objective of the hazard application. When much of the community near the coast is either severely threatened or significantly flooded by most category storms, it is not important to distinguish areas that may have small differences in predicted flood levels. In addition, there are limitations in accuracy for the SLOSH Model results.

One of the major concerns with the foregoing, however, is the depth of flooding. Figure 2-4 and the Atlas for Broward County give the storm tide elevations. Figure 2-5 is an attempt to estimate, in a very general way, the approximate depths of flooding at selected locations. However, these vary considerably depending on the specific location and should be specifically verified before using.

The major risks and hazards issues for Broward County are the following:

1. Wind and storm tide impacts on the barrier islands (e.g. Ft. Lauderdale Beach, Hollywood Beach and Pompano Beach).

2. Unusually high storm tide effects and flooding in the southern part of the county.

3. Extreme wind activity threatening the many high rise structures particularly on the barrier islands.

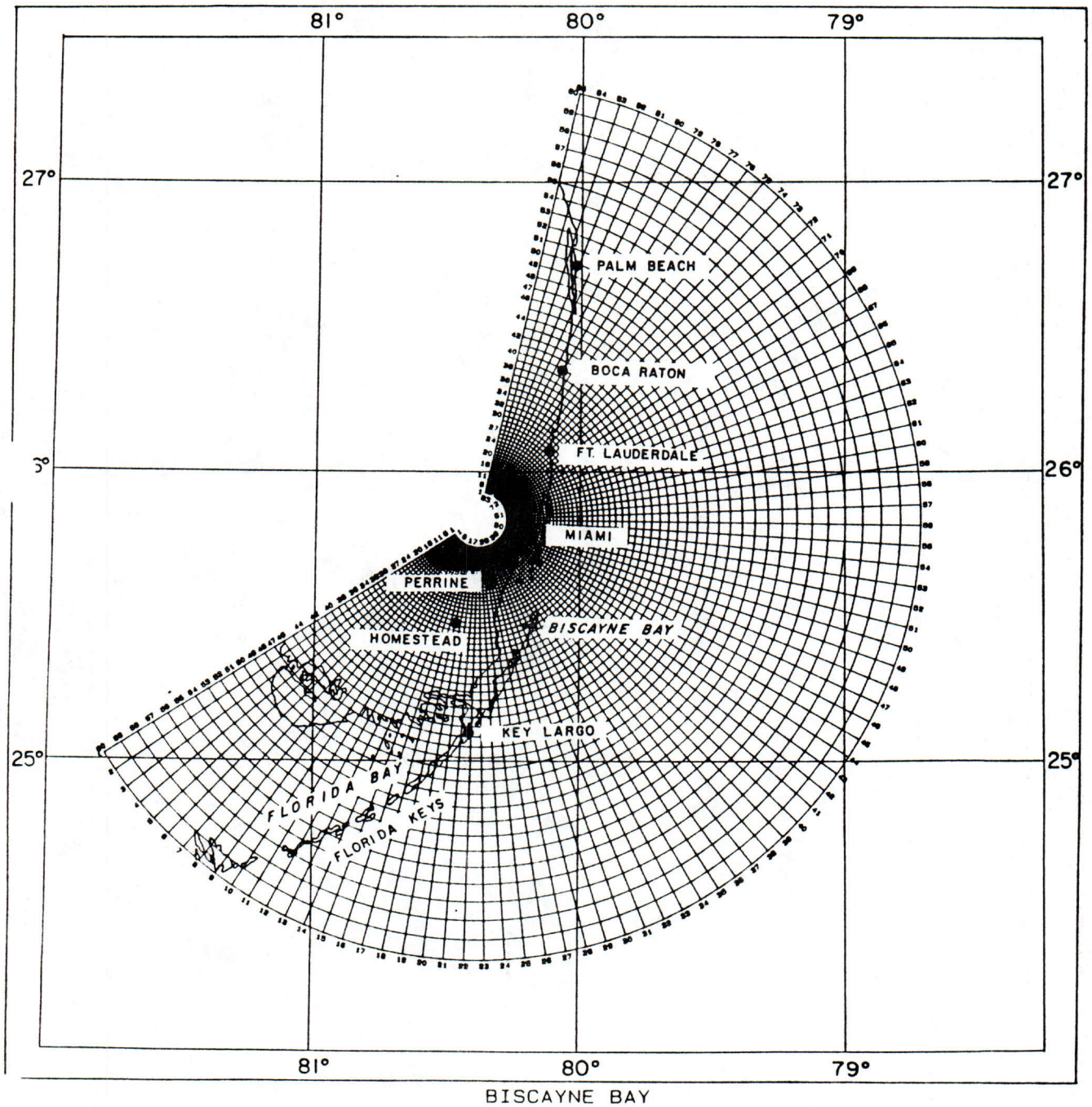
Any intense storm following a track through the Bahamas and generally bounded by the 270 and 292.5 degree lines, as shown on Figure 2-3, would offer extreme concern for the Broward County area. In the past these storms followed a west or west northwest heading and generally occurred in late August or the first part

of September. Because many of these storms stay north of Cuba and the Dominican Republic and, in some cases, Puerto Rico, they would not have been impeded by the significant land masses on these islands. The one exception was Hurricane King (1950) which began near Honduras and proceeded north. In addition, the 1947 storm approached very nearly in a westerly direction after passing generally along the northern perimeter of the Bahamas.

The Ft. Lauderdale area has not been directly threatened by a large storm since 1965 (some 25 years) although David provided a real test in 1979 before becoming a paralleling storm, for the most part. Although a threat, Hurricane Betsy in 1965 was considerably south of Ft. Lauderdale. And, even though the Florida Keys may appear to be more vulnerable, they have not been directly hit by a large storm since 1960 (Donna). The Keys lying generally along a line to the northeast provide a more suitable target for a storm moving in a west northwest direction (in terms of a direct, land falling strike). One other piece of historical evidence is worthy of mention here. Emergency planning has to emphasize the primary threats. All exiting hurricanes have been either Category 1 or 2 intensity storms. Although a Category 4 or 5 crossing (and exiting) storm is a possibility, it has not occurred in the 20th century.

The SLOSH model generates maximum wind values which agree well with the Saffir/Simpson Hurricane Scale range. Sustained winds for Category 3-5 could be expected to be in the 110-150 mile per hour range with gusts in the 140-200 mile per hour range. Evidence exists that a tremendous increase in damage and forces occur when winds move from the 90-100 mile per hour level to the 140-150 mile per hour level. Storm tide heights (elevations) consistent with the SLOSH Atlas are presented at various locations on Figure 2-4.

The foregoing risks are firm and one cannot escape the scope of those risks. The problems come in assuring the safety of residents of all areas. One thing that needs to be kept in mind about the hazard data is that it is for worst case situations. When a storm strikes it may only severely affect a part of Broward County. However, this is little consolation because there is no assurance whatsoever where that part will be. Broward County's coastline is not quite as extensive north to south as Dade and Palm Beach Counties. Thus, basically the entire county is always at risk when a large storm occurs. A major concern is depth of flooding. Table 2-1 is provided as a guide in determining the threats in selected areas. Obviously the flooding depths in the southern part of the county from Hollywood to the Las Olas area are greater than towards the northern part of the county. In addition, it is obvious that threats adjacent to the barrier islands and the Intracoastal Waterway are much greater for a large storm, than the risk near US 1.



Biscayne Bay SLOSH Grid

FIGURE 2-1

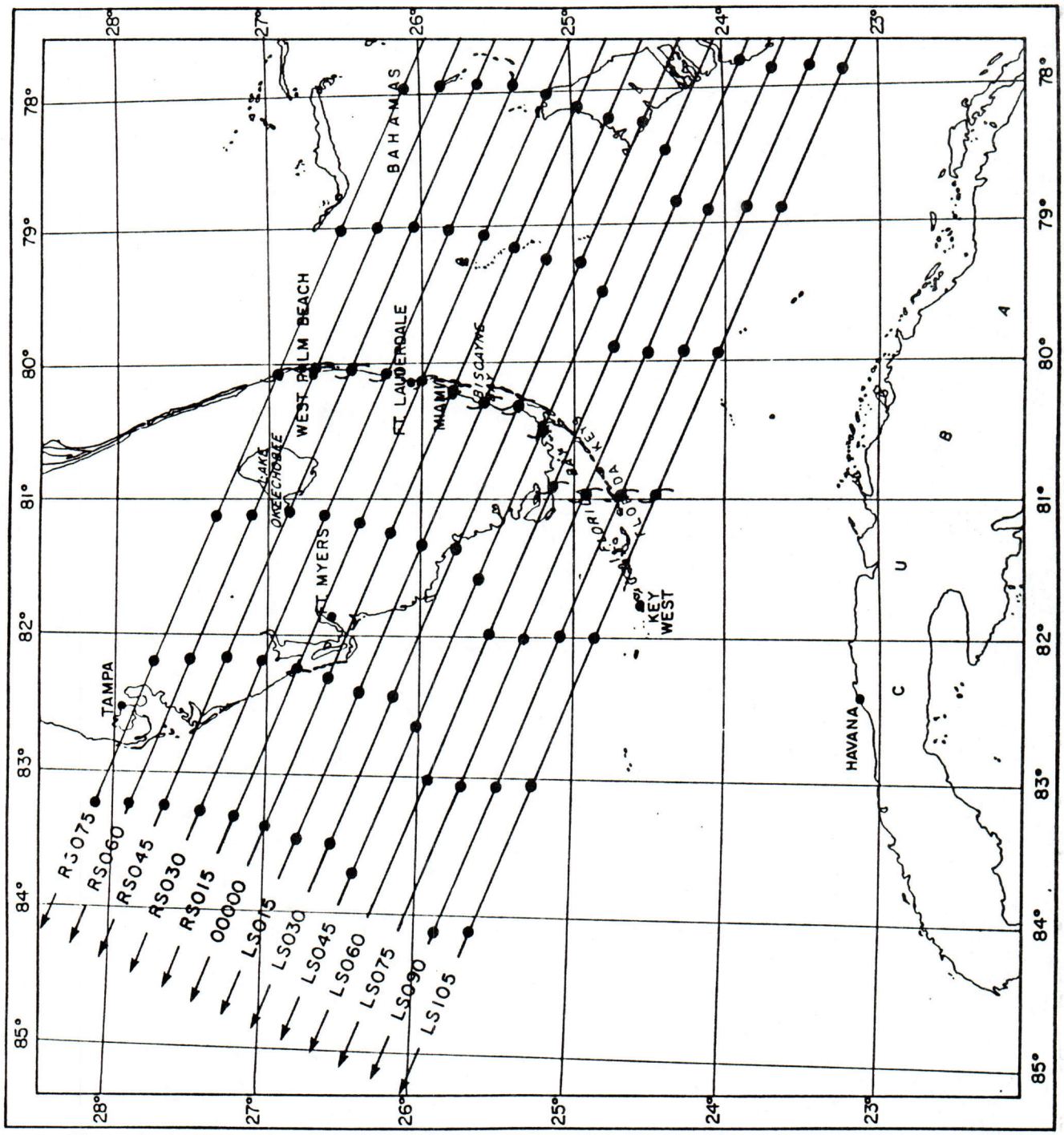


FIGURE 13.

Selected Headings and Tracks
from SLOSH Analysis

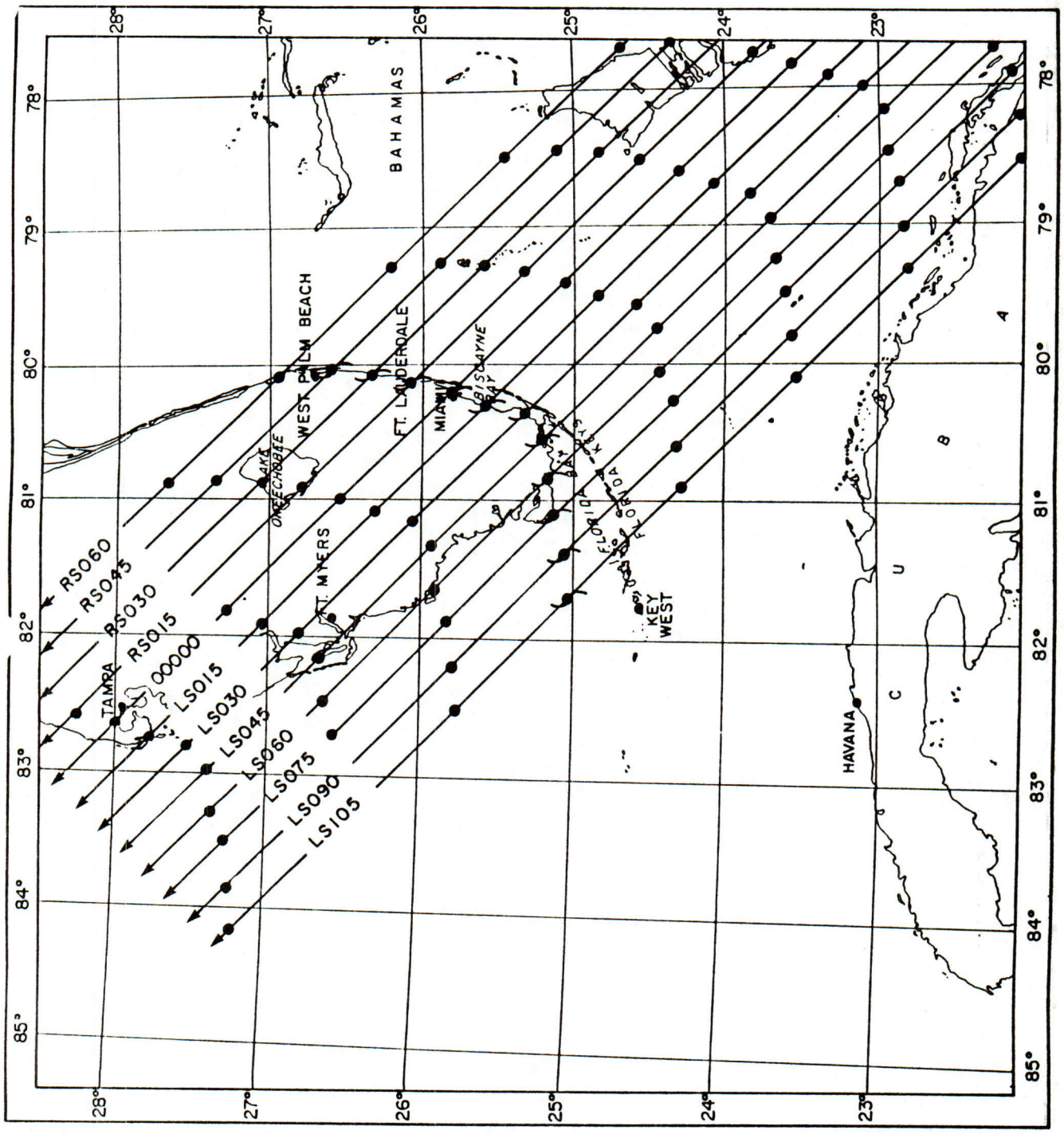
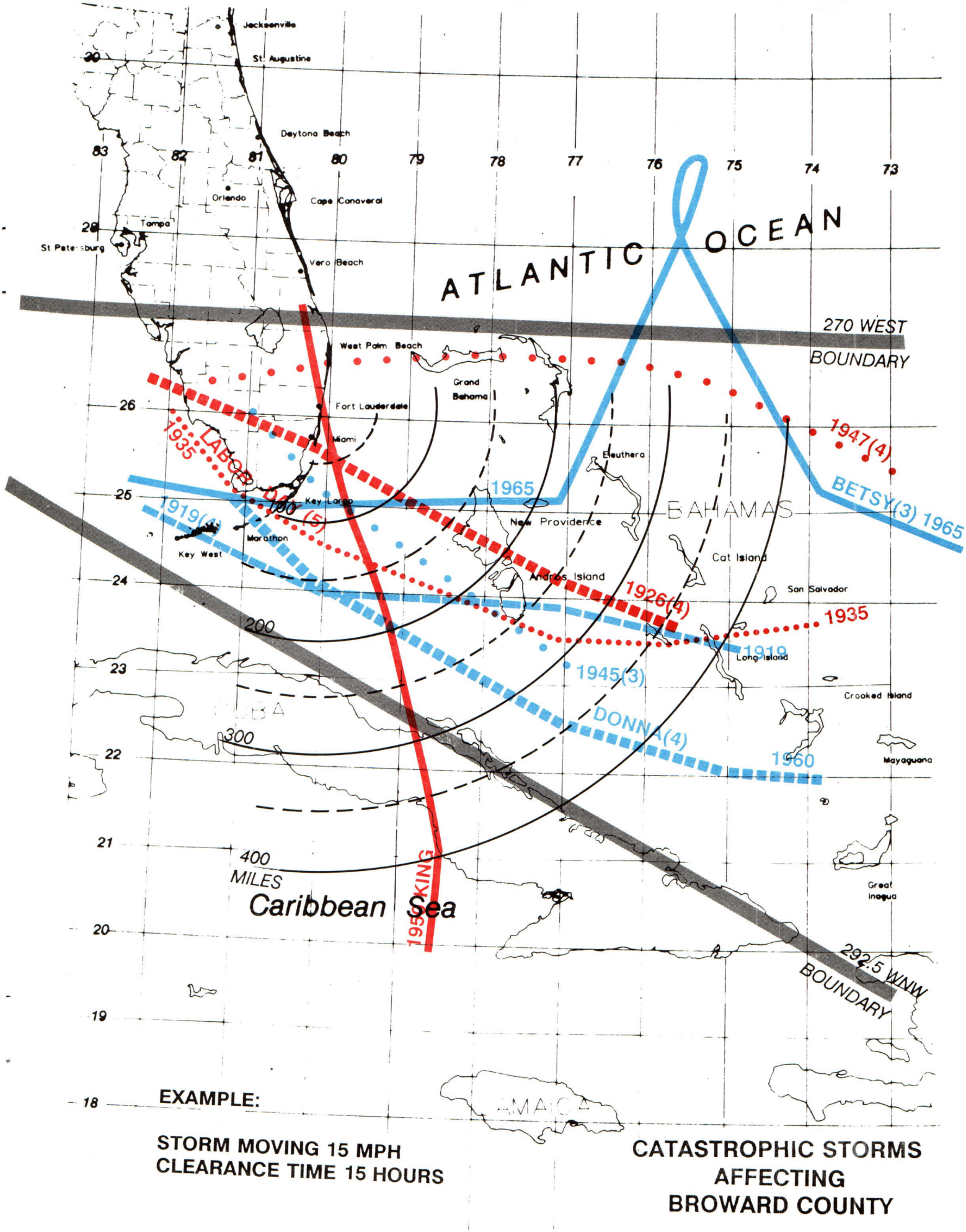


FIGURE 14.

Selected Headings and Tracks
from SLOSH Analysis

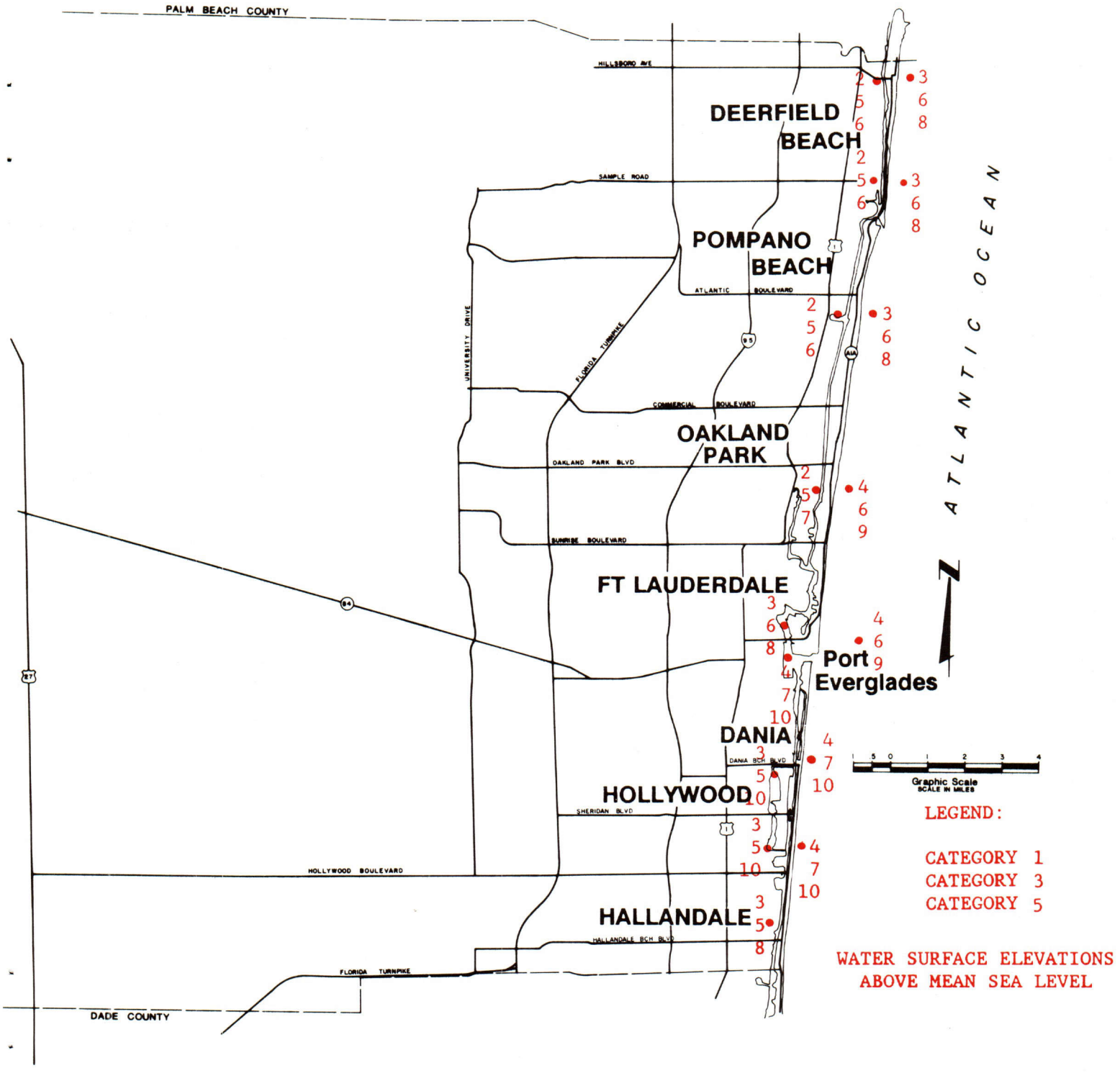
FIGURE 2-2



EXAMPLE:

STORM MOVING 15 MPH
CLEARANCE TIME 15 HOURS

CATASTROPHIC STORMS AFFECTING BROWARD COUNTY



BROWARD COUNTY

STORM TIDE HEIGHTS

FIGURE 2-4

TABLE 2-1

Approximate Depths of Flooding
at Selected Locations

Location	Approximate Ground Elevation	Storm Tide Elevations (Depths) Cat 1	Cat 3	Cat 5
Hollywood				
Barrier	4-5	4 (-)	7 (2-3)	10 (5-6)
Waterway	3-4	3 (-)	5 (1-2)	10 (6-7)
US 1	5	3 (-)	5 (-)	10 (5)
Las Olas				
Barrier*	5-6	4 (-)	6 (-)	9 (3-4)
Waterway	4	3 (-)	6 (2)	8 (4)
US 1	8-9	3 (-)	6 (-)	8 (-)
Oakland Park				
Barrier	4-6*	4 (-)	6 (2)	9 (3-5)
Waterway	4-5	2 (-)	5 (1)	7 (2-3)
US 1	5-10	2 (-)	5 (-)	7 (2)
Atlantic Blvd				
Barrier	4-6*	3 (-)	6 (2)	8 (2-4)
Waterway	3-5	2 (-)	5 (2)	6 (2-3)
US 1	8	2 (-)	5 (-)	6 (-)

Refer to the Storm Surge Atlas for Broward County for flooding verification.

*Flooded from waterway side (except for possible wave overtopping).

CHAPTER THREE
VULNERABILITY ANALYSIS

PURPOSE

The purpose of this Vulnerability Analysis is to identify the areas, populations, and facilities which are vulnerable to flooding associated with hurricanes. The storm surge data from the Hazards Analysis were used to develop inundation maps (see Hurricane Storm Tide Atlas for Broward County), evacuation zones, and evacuation scenarios; to quantify the population at risk under a range of hurricane intensities; and to identify major medical/institutional and other facilities especially shelters that are potentially vulnerable to storm surge.

HURRICANE EVACUATION ZONES

a. General. Evacuation zones have been developed for Broward County. Each of the evacuation zones are delineated as much as possible using major natural or manmade geographic features and conform to existing political or demographic boundaries (i.e., census tracts or traffic analysis zones) within the county. The purpose of this delineation is to aid in the development of population data to be used in traffic modeling; to determine sheltering requirements; and to facilitate future updating.

b. Zone Descriptions. Descriptions of the evacuation zones established for Broward County are contained in the appendices. Zone delineations are shown on Figure 3-1. This generally defines the vulnerabilities or areas at risk.

HURRICANE EVACUATION SCENARIOS

a. County Scenarios. Figure 3-1 and Table 3-1 and Chapter 6 contain the hurricane evacuation scenarios developed for Broward County and the transportation appendix lists the evacuation zones comprising each scenario. Maps illustrating each hurricane evacuation scenario are also contained in the transportation appendix. The analyses were performed on a county basis since evacuation decisions are made independently by each county.

b. Vulnerable Population. The vulnerable population within Broward County is comprised of those persons residing within the evacuation zones subject to storm surge, as well as the residents of mobile homes located in non-vulnerable zones. Due to their greater vulnerability to the strong winds associated with hurricanes, all mobile home residents are included in any evacuation. The total potential tourist population, based on the number of existing tourist units, is also included in the population of each evacuation zone. Table 3-1 shows the total number of persons identified for evacuation in the transportation modeling for each of the hurricane evacuation scenarios based on projected 1990 population data. The figures are presented early on here to give an idea of the scope of vulnerabilities.

c. Institutional/Medical Facilities. Inventories of institutional/medical facilities have been compiled for Broward County. One of the purposes of the Vulnerability Analysis is to determine which of these institutions may require evacuation under various hurricane threats. The first floor elevation of each

medical facility in or near areas vulnerable to storm surge has been established where appropriate. The data on inventories, capacities, surge analysis, and flood hazard evaluation for the institutional/medical facilities is maintained by Broward County emergency officials. A listing is contained in the appendices along with the vulnerability assessment for the facilities. The facilities listed in Table 3-2 have been identified as vulnerable and the residents are in need of movement during a large storm. Table 3-4 lists very recent additions to the vulnerability list. Table 3-3 list facilities that are borderline if a large storm in the Category 3-5 range should threaten them. Listed here are the capacities, the approximate ground elevation in the vicinity of the facility and the expected storm tide elevations for Category 3 and Category 5 storms. It may be that movement of the smaller facilities should be seriously considered assuming it could be accomplished fairly easily.

d. Shelters. Shelter inventories have been compiled and a list is shown on Table 3-5. The shelters are also listed in the appendices. Only one shelter identified earlier was deemed to be risky for use and it was the Attucks Middle School in Hollywood. It is suggested that this school not be used because, even for a large storm and high seasonal occupancy levels, there appears to be ample shelter capacity in the county even without this school. Thus, it was eliminated from the list. Only one of the shelters, Northeast High School, is affected by storm tide elevations resulting from large storms.

BROWARD COUNTY

VULNERABLE AREAS AND EVACUATION ZONES

FIGURE 3-1

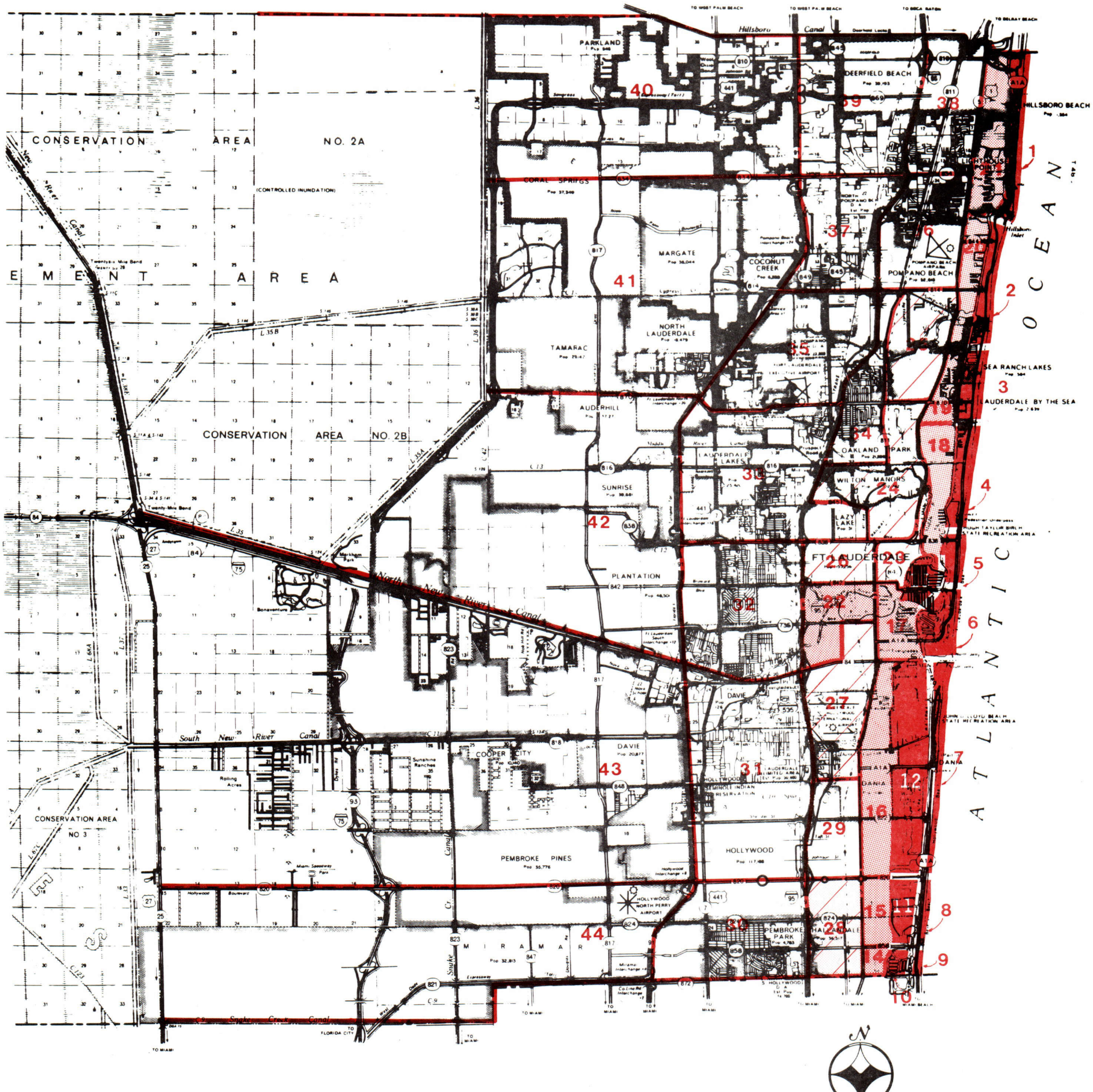


TABLE 3-1

EVACUATING PEOPLE STATISTICS

Storm Scenario	People Evacuating Dwelling Units	
Category 1-2 Hurricane Normal seasonal occupancy	187,355	
	130,610 (8,555)	[1]
	54,080	[2]
	2,665	[3]
	17,200-22,900	[4]
Category 1-2 Hurricane November seasonal occupancy	200,045	
	143,275 (21,220)	[1]
	54,080	[2]
	2,690	[3]
	21,750-29,000	[4]
Category 3 Hurricane Normal seasonal occupancy	300,570	
	241,675 (9,885)	[1]
	54,080	[2]
	4,815	[3]
	26,800-35,700	[4]
Category 3 Hurricane November seasonal occupancy	315,245	
	256,305 (24,515)	[1]
	54,080	[2]
	4,860	[3]
	32,050-42,700	[4]
Category 4-5 Hurricane Normal seasonal occupancy	426,680	
	364,160 (11,590)	[1]
	54,080	[2]
	8,440	[3]
	36,100-48,100	[4]
Category 4-5 Hurricane late November seasonal occupancy	443,895	
	381,310 (28,740)	[1]
	54,080	[2]
	8,505	[3]
	42,250-56,350	[4]

LEGEND:
[1] From Surge Zones
( ) visitors
[2] Mobile homes
[3] "Non-vulnerable" units
[4] Transit dependents

TABLE 3-1 (con't)

KEY ASSUMPTIONS:

1991 assumed base year population - 1,250,000

1991 Dwelling units interpolated from the 1987 and 1995 traffic analysis zonal data bases available through the Broward County Planning Office.

Occupancy of tourist/seasonal units - two levels (25% and 62%)

Figures include 100% of permanent and seasonal residents in surge zones and a small portion (1/2% - 1-1/2%) of the theoretically non-vulnerable population was also included in each scenario.

Transit dependents based on assumptions used in April 1986 memorandum from Broward County Office of Planning regarding population dependent on transit for hurricane evacuation. Figures shown in the table reflect a 75% to 100% range of participation of transit dependents.

TABLE 3-2

BROWARD COUNTY
INSTITUTIONAL/MEDICAL
VULNERABILITIES

FACILITY	CITY	EST. GROUND ELEV	CAT NO.	SURGE ELEV NGVD	REASON FOR SUGGESTED MOVEMENT (SEE CODE)
H.L.M. BOARDING HOME	DANIA	10.0	5	10.0	S
VILLA ERVEAN	DANIA	7.0	5	10.0	S,L
BILMAR GARDENS, INC.	DANIA	7.0	5	10.0	S,L
WILLOW MANOR RETIREMENT HOME	DANIA	4.0	3	5.0	L
SUNSHINE RETIREMENT	HALLANDALE	5.0	5	8.0	S,L
ABLE CARE RETIREMENT HOME	HOLLYWOOD	5.0	3	5.0	S,L
RAINBOW VILLAGE	HOLLYWOOD	5.0	5	10.0	S,L
ABBEY CARE CENTER	HOLLYWOOD	5.0	3	5.0	S,L
GOLD COAST RETIREMENT MANOR	HOLLYWOOD	7.0	5	10.0	S,L
SOUTHMOOR RETIREMENT HOME	HOLLYWOOD	7.0	5	8.0	S,L
PALM HOUSE	HOLLYWOOD	7.0	5	10.0	S,L
SE FOCAL POINT DAY CARE	HOLLYWOOD	7.0	5	10.0	S,L
AMBASSADOR RETIREMENT HOME	POMPANO BEACH	7.0	5	?	S,O
AMERICAN ELDERLY CARE	POMPANO BEACH	7.0	5	?	S,O
HARBOR LIGHTS RET HOME	POMPANO BEACH	7.0	5	?	S,O
MERI-LEE APT	POMPANO BEACH	5.0	5	6.0	S,O
OCEAN PARK MANOR	POMPANO BEACH	5.0	5	?	S,L,O
GOOD SHEPHARD RETIREMENT	POMPANO BEACH	7.0	5	?	O
ATLANTIC SHORE RET. HOME	POMPANO BEACH	5.0	5	6.0	S,L,O
GATEWAY RETIREMENT MANOR	FT.LAUDERDALE	5.0	3	7.0	S,L
OCEAN VIEW RET.HOME,INC	FT.LAUDERDALE	9.0	5	10.0	L
MEDALLION VILLAS RET.HOME	FT.LAUDERDALE	9.0	5	10.0	S,L
BAYVIEW RET.HOME,INC.	FT.LAUDERDALE	5.0	3	5.0	S,L
XANADU RETIREMENT	FT.LAUDERDALE	6.0	3	6.0	S,L
TIFFANY HOUSE	FT.LAUDERDALE	6.0	3	6.0	S,L
WILLIAMSBURG LANDING	WILTON MANORS	6.0	5	7.0	L
INDEPENDENCE HALL	WILTON MANORS	6.0	5	7.0	L
MARIGOLD RETIREMENT HOME	FT.LAUDERDALE	5.0	3	5.0	S,L
WINDSOR PLACE	WILTON MANORS	5.0	3	5.0	L
POINTE LAUDERDALE	OAKLAND PARK	6.0	5	7.0	L
GALT OCEAN MANOR(NEAR OCEAN)	FT.LAUDERDALE	10.0	5	9.0	O
HENRY'S RETIREMENT CENTER	FT.LAUDERDALE	5.0	3	6.0	L
MERRICK HOMES,INC.	FT.LAUDERDALE	6.0	5	7.0	L
THOMAS REST HOME	FT.LAUDERDALE	6.0	3	7.0	S,L
KING & QUEEN BD. HOME	FT.LAUDERDALE	6.0	3	7.0	S,L
NEW RIVER VILLAS	FT.LAUDERDALE	5.0	3	7.0	S,L
ALVES RETIREMENT HOME	FT.LAUDERDALE	5.0	3	7.0	S,L
SUNNY REACH ACRES	FT.LAUDERDALE	4.0	3	7.0	S,L
FICUS MANOR	FT.LAUDERDALE	6.0	3	6.0	S,L
RIVER DRIVE RET.HOME	FT.LAUDERDALE	6.0	3	7.0	S,L
SOUTHSIDE MANOR	FT.LAUDERDALE	6.0	3	7.0	S,L

CODE:
L - LOW
S - SMALL
O - NEAR OCEAN

TABLE 3-3

BROWARD COUNTY
INSTITUTIONAL/MEDICAL
VULNERABILITIES

FACILITY	CITY	EST. GROUND ELEV.	CAPACITY	STORM ELEV CAT 3	TIDE ATIONS CAT 5
SUNNY ISLES RET.HOME INC	FT.LAUDERDALE	6.0	08	5.0	6.0
ABUNDANT CARE RETIREMENT	OAKLAND PARK	7.0	21	5.0	7.0
NORTH RIDGE RET.HOME	FT.LAUDERDALE	6.0	08	5.0	6.0
McEACHERN ACLF	WILTON MANORS	6.0	08	5.0	6.0
EDWARD'S LOVING HOME CARE	FT.LAUDERDALE	6.0	09	5.0	6.0
SUPREME RETIREMENT HOME	WILTON MANORS	6.0	12	5.0	6.0
HOLLY HEIGHTS MANOR	FT.LAUDERDALE	5.0	65	5.0	6.0
MILLER'S QUALITY CARE	DEERFIELD BEACH	10.0	05	5.0	6.0
HOWELL'S RETIREMENT HOME	OAKLAND PARK	6.0		5.0	7.0

TABLE 3-4
ADDITIONAL
INSTITUTIONAL/MEDICAL
VULNERABILITIES

FACILITY	CITY	EST. GROUND ELEV.	STORM ELEV CAT 2	TIDE ATION CAT 3
DANIA NURSING HOME	DANIA	5-6	6	8
BROWARD CONV. HOME	FT. LAUDERDALE	7-8	6	8
NORTH RIDGE RET HOME ACLF	FT. LAUDERDALE	5-6	5	6
PALM COURT NURSING & REHAB CTR	FT. LAUDERDALE	5-6	5	7
MANOR PINES CONV.	FT. LAUDERDALE	5-6	5	7
SUNNYREACH ACRES ADC ACLF	FT. LAUDERDALE	5-6	7	10
HOLLY HEIGHTS MANOR ACLF	FT. LAUDERDALE	7-8	7	10
COMMUNITY RE-ENTRY CTR ACLF	FT. LAUDERDALE	4-5	6	8
SHADOWWOOD ACLF	FT. LAUDERDALE	6	7	10
HARBOR BEACH CONV HOME	FT. LAUDERDALE	10	7	10
MONTICELLO MANOR NURSING HOME	FT. LAUDERDALE	5	6	9
GOLFCREST NURSING HOME	HOLLYWOOD	7-8	5	10
MERRIMENT MANOR RET HOME ACLF	HOLLYWOOD	8-9	5	10
NORTHLAKE RET HOME ACLF	HOLLYWOOD	7-8	5	10
SEASIDE VILLA ACLF	POMPANO BEACH	6-7	5	6

TABLE 3-5

SHELTERS

FACILITY	CITY	FLOOD INSUR RATE MAP #	FLOOD INSUR ZONE	ZONE ELEV NGVD	CAPA-CITY	GROUND ELEV NGVD	CAT 5 ELEV NGVD
1 .COCONUT CREEK HIGH	COCONUT CREEK	0005	A1	14.	5750	7.0	
2. CORAL SPRINGS HIGH	CORAL SPRINGS	0005	C		4250		
3. DEERFIELD BEACH HI	DEERFIELD BEACH	C0125	C		5750	17.0	
4. ELY HIGH	POMPANO BEACH	0010	B		5350		
5. MARGATE MIDDLE	MARGATE	0001	C		2500		
6. SILVER LAKES	NORTH LAUDERDAL	0001	B		3000		
7. POMPANO BEACH MID	POMPANO BEACH	0010	C		2500	17.0	
8. TAMARAC ELEMENTARY	TAMARAC	0002	A2	11.	1500		
9. TARAVILLA HIGH	CORAL SPRINGS	0005	C		5400		
10. BOYD ANDERSON HI	LAUDERDALE LAKE	0001	A3	8.0	5750	6.0	
11. CASTLE HILL ELEM.	LAUDERHILL	0005	A3	8.0	925	6.0	
12. DILLARD HIGH	FT LAUDERDALE	0010	A2	8.0	6500	7.0	
13. NORTHEAST HIGH	OAKLAND PARK	0001	A2	7.0	4500	5	6*
14. PLANTATION HIGH	PLANTATION	0002	A2	8.0	4250	7.0	
15. PIPER HIGH	SUNRISE	0010	A1	9.0	5350		
16. SO. PLANTATION HI	PLANTATION	0002	A2	7.0	4250	6.0	
17. WESTERN HIGH	DAVIE	0005	AE	7.0	5225		
R23.SHERIDAN HILLS ELE	HOLLYWOOD	0025	A2	7.0	1800		
R18.HALLANDALE HIGH	HALLANDALE	0001	C		5425		
R19.HOLLYWOOD HILLS	HOLLYWOOD	0025	A2	7.0	4900	7.0	
R20.MIRAMAR HIGH	MIRAMAR	0002	A1	7.0	3250		
R22.PIONEER MIDDLE	COOPER CITY	0001	A1	7.0	3375		
WALTER C YOUNG	PEMBROKE PINES	0001	A1	7.0	??		

CHAPTER FOUR
SHELTERS

GENERAL

Shelter inventories have been compiled and are listed in the appendices along with their vulnerabilities. As discussed in Chapter Three, only two shelters identified throughout the study were deemed to be risky for use. They were the Attucks Middle School in Hollywood and the Northeast High School in Oakland Park. It is suggested that these schools not be used because, even for a large storm and high seasonal occupancy levels, there appears to be ample shelter capacity in the county without them.

Shelter capacities are based on a 20 square feet per person figure agreed upon after much discussion between Red Cross Officials and Broward County Emergency Management staff. To say that there appears to be ample shelter in the county is probably an understatement. Seldom has there ever been occupancy of shelters even approaching the percentage of evacuees derived from the behavioral analyses. Broward County is not expected to be any exception to this rule.

CHAPTER FIVE
BEHAVIORAL ANALYSIS

PURPOSE

The purpose of the Behavioral Analysis is to provide public evacuee response data for use in the Shelter Analysis, Transportation Analysis, and for guidance in emergency decision-making and public awareness efforts. The study included representation from the residential population residing in high-risk (barrier islands), medium-risk (mainland evacuation zones), and low risk (wind affected only) areas. The study determined evacuation rates, timing, vehicle use, destinations, and types of shelters sought.

OBJECTIVES

The specific objectives of the Behavioral Analysis were to determine the following:

a. Evacuation rates: The percentages of the resident and tourist population in both low-risk, medium-risk, and high-risk areas that would evacuate under various hurricane conditions.

b. Evacuation timing: The response times of the threatened population in low-risk, medium-risk, and high-risk areas to an evacuation advisory or order.

c. Vehicle use: The numbers and types of vehicles that would be used in the Broward County area in a hurricane evacuation.

d. Destinations of the Broward County population in low-risk, medium-risk, and high-risk areas.

e. Types of refuge such as public shelters, homes of friends or relatives, motels, etc. preferred by Broward County evacuees under a hurricane threat.

DATA ANALYSIS

The primary analytical tool used to obtain the behavioral information was a General Response Model which is discussed in detail in the Behavioral Appendix. The General Response Model indicates how selected behaviors vary as a function of specific situations and circumstances in a study area.

Data gathered on actual responses to hurricanes David and Floyd in Dade, Broward and Palm Beach Counties and to hurricane David in the Treasure Coast region, just north of the study area, were used to test the predictive ability of the General Response Model and as a basis for calibrating the model to the study area.

A second model, an Intended Response Model, was also developed for the study. The Intended Response Model was similar to the General Response Model, but was based on intended responses obtained from households in the study area.

The results of the General Response Model which were based on actual behavior patterns were compared with Intended Response Model results which were based on hypothetical behavior responses to yield the final projections for the selected behaviors in the study area.

COLLECTION OF INTENDED RESPONSE DATA

Data for the Intended Response Model were obtained by means of a stratified random sample of households in Broward County. Residents were telephoned and interviewed concerning hurricane evacuation intentions, past experience, and demographic information which could predict response. In Broward County, 200 respondents were interviewed with phone numbers selected from cross-reference directories. Half the interviews were conducted with people living in beach areas and half with mainland residents within areas which would probably need to evacuate in major hurricanes.

ANALYSIS RESULTS

The following paragraphs present the results of the study in terms of each of the specific objectives established Behavioral Analysis.

a. Evacuation Timing. Regardless of the proficiency of emergency management officials, circumstances will arise in which very prompt evacuation is necessary, and residents will respond accordingly. In other cases, the notice will be issued earlier, and evacuation can and will proceed more leisurely. For planning purposes, the three different timing response curves shown in the Behavioral Appendix should be considered, because eventually Southeast Florida will experience all three. In each threat scenario, occupants of lower risk areas will tend to wait longer to evacuate than those lining in more hazardous locations.

b. Vehicle Use. For each locations available, vehicle use will be between 65% and 75%. For mainland locations, it will vary from 60% to 70%. The variation in intention to pull trailers and take motorhomes probably reflects variation in ownership from place to place, but with samples of just 100 in each location, not too much should be made of the variations. Overall only 3 to 5 percent of evacuees will pull trailers or take motorhomes.

c. Evacuation Rates. Table 5-1 summarizes the evacuation rates which should be used for planning. Recommendations are stratified on four dimensions: risk area, action by public officials, and strength of storm, and type of house.

TABLE 5-1

EVACUATION RATES TO BE USED FOR PLANNING

Severe Storm Evacuation Ordered in High and Moderate Risk Areas and Mobile Homes			Weak Storm Evacuation Ordered in High Risk Areas Only But All Mobile Homes		
Risk Area					
High	Med	Low	High	Med	Low
Housing Other Than Mobile Homes					
90%+	80%	30%	85%	40%	20%
Mobile Homes					
95%	90%	80%+	90%	75%	65%

d. Destinations. Table 5-2 indicates the percentage of evacuees that will leave their own county from each of three risk areas and in each of two threat scenarios. The first threat is a very severe hurricane (Category 3 or greater) in which people are told in plenty of time to evacuate, say 24 hours before expected landfall. More people will leave their own county in that sort of circumstance. Planning assumptions derived from the Behavioral Survey for people going to shelters are contained in Table 4-3.

TABLE 5-2

PLANNING ASSUMPTIONS
PERCENT OF EVACUEES LEAVING COUNTY

Very Strong Storm Early Evacuation			Weak Storm Typical Timing		
Risk Area			Risk Area		
High	Med	Low	High	Med	Low
50%	35%	20%	35%	20%	15%

Low income evacuees seldom evacuate very far, and the rates in Table 5-2 should be at least 20 points lower for those groups. For last minute evacuations in which evacuees do not have the luxury of driving very far, particularly late at night, the figures will also be lower than those in Table 5-2.

TABLE 5-3

PLANNING ASSUMPTIONS
EVACUEES GOING TO PUBLIC SHELTERS

	RISK AREA		
	HIGH	MED	LOW
INCOME			
High	10%	10%	5%
Medium	20%	15%	10%
Low	35%	30%	25%

These were the planning guides. However, specific percentages that were used in the transportation modeling process are contained in the Transportation Appendix to this report.

CHAPTER SIX
TRANSPORTATION ANALYSIS

GENERAL

During a hurricane evacuation effort, it is widely recognized that a large number of vehicles have to be moved across a road network in a relatively short period of time. The number of vehicles and evacuees becomes particularly significant for an area such as Broward County, Florida where causeways connect many urban areas and seasonal communities. The magnitude of evacuating vehicles varies depending upon the intensity of the hurricane, presence of tourists, and certain behavioral response and participation characteristics of the vulnerable population.

Vehicles enter the road network at different times depending on the evacuee's response relative to an evacuation order or advisory. Conversely, vehicles leave the road network depending on both the planned destinations of evacuees and the availability of acceptable destinations such as public shelters, hotel/motel units and friends' or relatives' homes in non-flooded areas. Vehicles move across the road network from trip origin to destination at a speed dependent on the traffic loadings on various roadway segments and the ability of the segments to handle a certain volume of vehicles each hour.

The overall goals of the transportation analysis performed for the Broward County portion of the Lower Southeast Florida Hurricane Evacuation Study were to estimate clearance times (the time it takes to clear the county's roadways of all evacuating vehicles), to define the evacuation road network, and to look at general traffic control measures that could improve traffic flow along critical roadway segments. Clearance time is a value resulting from transportation engineering analysis performed under a specific set of assumptions. It must be coupled with marine advisory data to determine when a strong evacuation advisory must be issued to allow all evacuees time to reach safe shelter before the arrival of sustained tropical storm winds. Factors that influence clearance time must be studied intensively to determine which factors have the strongest influence. Therefore, a sensitivity analysis was performed and approximately 100 clearance times calculated by varying key input parameters.

The transportation analysis task initially identified the kinds of traffic movements associated with a hurricane evacuation that must be considered in the development of clearance times. Basic assumptions for the transportation analysis were then developed related to storm scenarios, population-at-risk, behavioral and socioeconomic characteristics, the roadway system and traffic control. A transportation modeling methodology and a roadway system representation were developed for the study area to facilitate model application and development of clearance times. General information and data related to the transportation analysis are presented in summary form in the Transportation Appendix. A Transportation Model Support Document is available through the Jacksonville District Corps of Engineers and includes a detailed account of all transportation modeling activities and zone by zone data listings for Broward County.

Table 6-1

EVACUATING PEOPLE STATISTICS

Storm Scenario	People Evacuating Dwelling Units	Going to Public Shelter
Category 1-2 Hurricane Normal seasonal occupancy	187,355 130,610 (8,555) [1] 54,080 [2] 2,665 [3] 17,200-22,900 [4]	28,510
Category 1-2 Hurricane November seasonal occupancy	200,045 143,275 (21,220) [1] 54,080 [2] 2,690 [3] 21,750-29,000 [4]	29,780
Category 3 Hurricane Normal seasonal occupancy	300,570 241,675 (9,885) [1] 54,080 [2] 4,815 [3] 26,800-35,700 [4]	40,105
Category 3 Hurricane November seasonal occupancy	315,245 256,305 (24,515) [1] 54,080 [2] 4,860 [3] 32,050-42,700 [4]	41,570
Category 4-5 Hurricane Normal seasonal occupancy	426,680 364,160 (11,590) [1] 54,080 [2] 8,440 [3] 36,100-48,100 [4]	62,070
Category 4-5 Hurricane late November seasonal occupancy	443,895 381,310 (28,740) [1] 54,080 [2] 8,505 [3] 42,250-56,350 [4]	63,790

LEGEND:
[1] From Surge Zones
( ) visitors
[2] Mobile homes
[3] "Non-vulnerable" units
[4] Transit dependents

TABLE 6-1 (con't)

KEY ASSUMPTIONS:

1991 assumed base year population - 1,250,000

1991 Dwelling units interpolated from the 1987 and 1995 traffic analysis zonal data bases available through the Broward County Planning Office.

Occupancy of tourist/seasonal units - two levels (25% and 62%)

Figures include 100% of permanent and seasonal residents in surge zones, all mobile home residents and a small portion (1/2% - 1-1/2%) of the theoretically non-vulnerable population.

Transit dependents based on assumptions used in April 1986 memorandum from Broward County Office of Planning regarding population dependent on transit for hurricane evacuation. Figures shown in Table 6-2 and 6-3 reflect a 75% to 100% range of participation of transit dependents.

TABLE 6-2

EVACUATING TRANSIT DEPENDENTS
(75% participation)

Evacuation Zone	Cat 1-2 Normal Occupancy	Cat 1-2 Nov Occupancy	Cat 3 Normal Occupancy	Cat 3 Nov Occupancy	Cat 4-5 Normal Occupancy	Cat 4-5 Nov Occupancy
1	850	1,110	850	1,110	850	1,110
2	1,401	1,849	1,401	1,849	1,401	1,849
3	1,123	1,583	1,123	1,583	1,123	1,583
4	1,314	1,784	1,314	1,784	1,314	1,784
5	1,068	2,122	1,068	2,122	1,068	2,122
6	953	1,556	953	1,556	953	1,556
7	810	1,255	810	1,255	810	1,255
8	1,987	2,584	1,987	2,584	1,987	2,584
9	820	942	820	942	820	942
10	301	301	301	301	301	301
11	1,387	1,387	1,387	1,387	1,387	1,387
12	227	244	227	244	227	244
13	499	581	499	581	499	581
14	0	0	160	160	160	160
15	7	7	2,259	2,395	2,259	2,395
16	30	30	1,352	1,451	1,352	1,451
17	21	21	1,229	1,571	1,229	1,571
18	0	0	769	773	769	733
19	0	0	426	426	426	426
20	6	6	521	521	521	521
21	0	0	1,274	1,281	1,274	1,281
22	0	0	1,658	1,780	1,658	1,780
23	0	0	0	0	874	980
24	0	0	0	0	2,203	2,488
25	72	72	72	72	1,393	1,483
26	0	0	0	0	1,212	1,250
27	0	0	0	0	126	827
28	129	129	129	129	3,195	3,382
29-44	4,197	4,197	4,197	4,197	4,197	4,197
TOTALS	17,201	21,759	26,786	32,054	36,089	42,263

TABLE 6-3

EVACUATING TRANSIT DEPENDENTS
(100% participation)

Evacuation Zone	Cat 1-2 Normal Occupancy	Cat 1-2 Nov Occupancy	Cat 3 Normal Occupancy	Cat 3 Nov Occupancy	Cat 4-5 Normal Occupancy	Cat 4-5 Nov Occupancy
1	1,133	1,480	1,133	1,480	1,133	1,480
2	1,868	2,465	1,868	2,465	1,868	2,465
3	1,497	2,111	1,497	2,111	1,497	2,111
4	1,752	2,378	1,752	2,378	1,752	2,378
5	1,424	2,829	1,424	2,829	1,424	2,829
6	1,271	2,075	1,271	2,075	1,271	2,075
7	1,080	1,673	1,080	1,673	1,080	1,673
8	2,650	3,446	2,650	3,446	2,650	3,446
9	1,093	1,256	1,093	1,256	1,093	1,256
10	401	401	401	401	401	401
11	1,849	1,849	1,849	1,849	1,849	1,849
12	303	325	303	325	303	325
13	665	775	665	775	665	775
14	0	0	214	214	214	214
15	10	10	3,012	3,193	3,012	3,193
16	40	40	1,803	1,935	1,803	1,935
17	27	27	1,639	2,095	1,639	2,095
18	0	0	1,025	1,030	1,025	1,030
19	0	0	568	568	568	568
20	8	8	695	695	695	695
21	0	0	1,699	1,708	1,699	1,708
22	0	0	2,211	2,374	2,211	2,374
23	0	0	0	0	1,165	1,306
24	0	0	0	0	2,937	3,317
25	95	95	95	95	1,858	1,977
26	0	0	0	0	1,616	1,667
27	0	0	0	0	834	1,103
28	172	172	172	172	4,260	4,509
29-44	5,596	5,596	5,596	5,596	5,596	5,596
TOTALS	22,934	29,011	35,715	42,738	48,118	56,350

TRANSPORTATION MODELING

CLEARANCE TIMES

The transportation modeling for Broward County is not affected dramatically by additional tourists in the area during the hurricane season. It is affected dramatically when significant areas are additionally inundated as the result of higher storm tide values for the Category 4 and 5 storms. Reference is made to the storm tide values shown in Figure 2-4, Chapter Two, Hazards Analysis.

One key consideration is that the numbers of persons (or evacuees) loaded on the travel network is based on "worst case" conditions for each scenario, i.e., Cat 1-2, Cat 3, and Cat 4-5. Depending on the movement of the storm and other specific factors the decision to evacuate may not be made for certain lesser storms (category 1 and 2). Even though risky, the closer the Emergency Manager can allow the storm to come before making the decision to evacuate, the more accurate the decision on the scope of evacuation. This is important and the Decision Arcs (in the following chapter) and the HURREVAC computer model are important aids in making the decision. However, because Broward County is relatively narrower north to south, the whole county will be impacted if Ft. Lauderdale has a high probability and the intensity becomes extremely important.

Results of the transportation modeling for Broward County are shown on Table 6-4. These are the times that should be used when managers go to the Decision Arcs and/or to the HURREVAC computer model to arrive at decision times for Broward County.

The fact that the table presents clearance times for a Category 1 hurricane scenario, does not mean that an evacuation order is necessary. While evacuation, at best, is very expensive and chaotic(e.g. Hurricane David in 1979), it may well be too risky not to evacuate.

Of course, the Category 4-5 scenario is most critical because it involves the most people and presents the storm scenario that we all fear. The manager must ascertain those steps which will dramatically affect or reduce the clearance time. Then the response strategies that will give the best response under the given situation must be determined. Suggestions for these strategies and stages of evacuation are outlined in the next section, "Response and Strategies".

From Table 6-4, the following are critical determinations:

a. Requiring vulnerable tourists to leave Broward County as early as possible could reduce clearance times some but does not appear to be a critical factor.

b. The immediate or rapid (as opposed to slow) response could give a 3 to 4 hour edge. (Probably directly dependent on the urgency of the appeal from public officials).

The foregoing steps are a consideration in the reduction of clearance times and in no way reflect the reality that it will (or will not) happen this way. This is important because, for planning purposes, the closest match-up of

theoretical and actual movements must be obtained.

As mentioned in the notes following Table 6-4 local plans call for busing a very large population during a large storm. It is suggested that busing would need to begin some 30 hours in advance of storm hazards. This equates closely with the sum of the computed clearance times and anticipated "pre-land fall hazard" times. Utilizing the tropical force wind information from the NOAA marine advisories and the storm plot overlay should account for this extra time needed. A total of 30 hours coupled with a relatively slow moving storm, say 15 mph, would still give 450 miles which is quite a distance out. Movement, at this point, of a significant block of evacuees would have to be balanced against the probabilities of the storm hitting Ft. Lauderdale and will depend greatly on the intensity of the storm at that point. Certainly, the buses could be moved into position at this time.

Table 6-4
CLEARANCE TIMES*
(in hours)

CATEGORY 1-2	SUMMER SEASONAL OCCUPANCY	LATE FALL/NOVEMBER SEASONAL OCCUPANCY
Rapid Response	11.25	11.5
Medium Response	12.5	13
Slow Response	14.25	14.75
CATEGORY 3		
Rapid Response	16.25	16.5
Medium Response	17.5	18
Slow Response	19.25	19.75
CATEGORY 4-5		
Rapid Response	21.5	22
Medium Response	23.25	24
Slow Response	25.75	26.5

NOTES:

* Clearance times reflect congestion levels expected on local Broward County roads for traditional automotive evacuation. Clearance times for residents going out of county will be much higher for certain scenarios(see Palm Beach County clearance time tables in Transportation Appendix, for information on the Florida Turnpike and I-95).

It is important to note that in a worse case situation, local plans call for evacuation of close to 50,000 people using public transportation (buses). The mobilization, routing, and carrying capacity of this type of operation will require greater times than those shown above. Local estimates are that buses would need to begin operating approximately 30 hours in advance of storm hazards to service this many evacuees.

CHAPTER SEVEN
DECISION CONCEPTS AND ARCS

GENERAL

Decision making information for Broward County was developed with heavy consideration to historical information relating to the most damaging modern day storms to hit the County. Without question, the greatest risks for Broward County are from intense storms coming from the east (generally, called "Cape Verde" storms) through the Bahamas that have not been impeded by significant land masses such as Cuba and the Dominican Republic. These storms have the following common characteristics (especially, the 1919, 1926 1935, 1947, 1960, and 1965 storms):

a. They occurred very early (or sometime) in September.
b. They stayed north of Cuba and the Dominican Republic. Most passed north of Puerto Rico.
c. All came through the mid or lower Bahamas.
d. All were on west or west-northwest headings
e. None passed over large bodies of land (or mountains) that may have caused some loss of energy.

The storm paths are included in Figure 2-3. Hurricane King in 1950 was an exception approaching from the south.

Previously developed data included "pre-landfall hazards times" generated from the SPLASH model to define tropical force wind arrivals relative to storm landfall. The new SLOSH models for the area also provide this information. However, it has been determined more appropriate to obtain the tropical force wind information from NOAA marine advisories where it is provided in terms of distances in miles from the center of the storm. Thus, if one knows the precise location of the storm, arcs defining the extent of the tropical force winds can be developed using the location of the storm as the center. The point where the tropical force wind arc intersects an arc defining a specific evacuation (or clearance) time converted to distance, would determine when, or at what storm location, the evacuation should begin.

To facilitate the foregoing determinations, a set of tables were developed for a number of storm speeds matching clearance times and distances. These were then converted to a set of lines relating evacuation time and distances. The relationships are included in Figure 7-1. If one knows the approximate time needed for evacuation (from the transportation modeling), the point where the evacuation needs to begin can be determined. This can be called the decision maker's "arc of interest". The figure is set up for knots and nautical miles but MPH can be used and statue miles determined also.

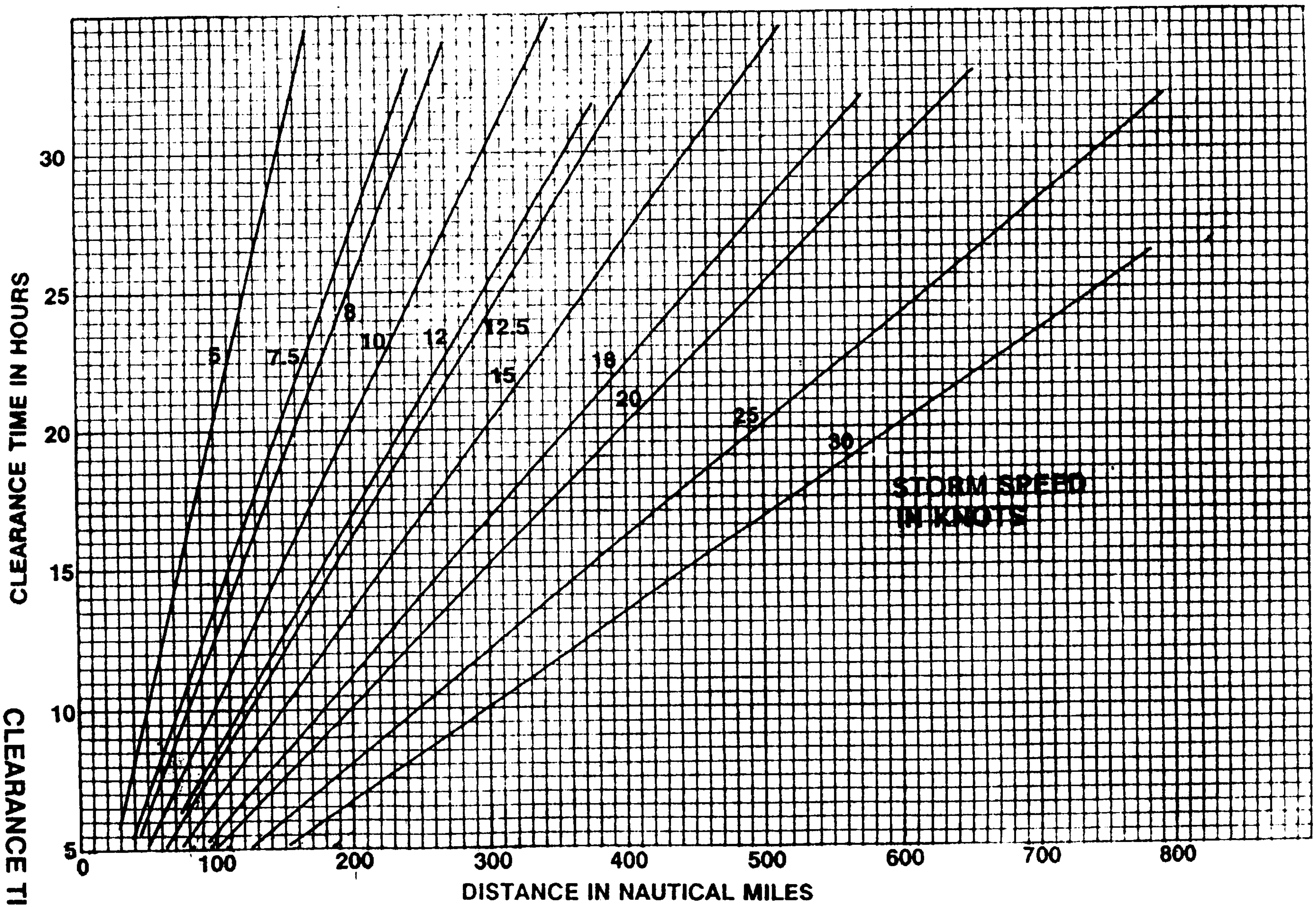
The only thing that the decision makers then need to determine is where the storm center will be when the tropical force winds arrive at the "arc of interest". They can readily determine the current position and location in miles from their place of interest from the advisories and through plotting on the decision chart. From the advisories, they then obtains the extent of the tropical force winds in miles and subtracts that from the center of storm

location in miles to see where the tropical force winds are now. Then determine the difference in miles between this point and their "arc of interest" thus determining the distance the hurricane must move. Knowing the storm speed, one then knows how many hours are available before the tropical force winds reach their arc of interest. An example is provided on Figures 7-2 and 7-3 for determination of the critical values. The example uses mph and statute miles. In addition, the information from the advisories is in knots and nautical miles.

Table 7-1 portrays clearance times for three response levels and two tourist occupancy levels. Clearance times were then converted to distances for various storm speeds in knots and matched with a lettered decision arc on Figure 7-4. Distances were rounded to match the next highest arc (or the next one away from the center). This decision arc then becomes the "arc of decision" for the emergency manager. A storm plot overlay, included in Figure 7-5,to aid in determination of a specific storm and storm center where certain tropical force wind arcs intersect the clearance arc of interest.

DETAIL

A Hurricane Evacuation Decision Worksheet and a discussion of the HURREVAC computer model are provided for guidance at the end of this report in Annex I.



CLEARANCE TIMES
STORM SPEEDS
AND DISTANCES
FIGURE 7-1

DECISION ARC INFORMATION

EXAMPLE

1. Determine Arc of Interest from lines Figure 7-1.
   Example: 15 hours clearance time needed.
   Storm moving 15 mph = 225 miles.

2. Determine location of storm center from advisory.
   Example: Longitude 75.7
   Latitude 22.7 @ 400 miles

3. Determine Extent of tropical force winds from advisory.
   Example: tropical force winds extend 150 miles
   400 - 150 = 250 miles location

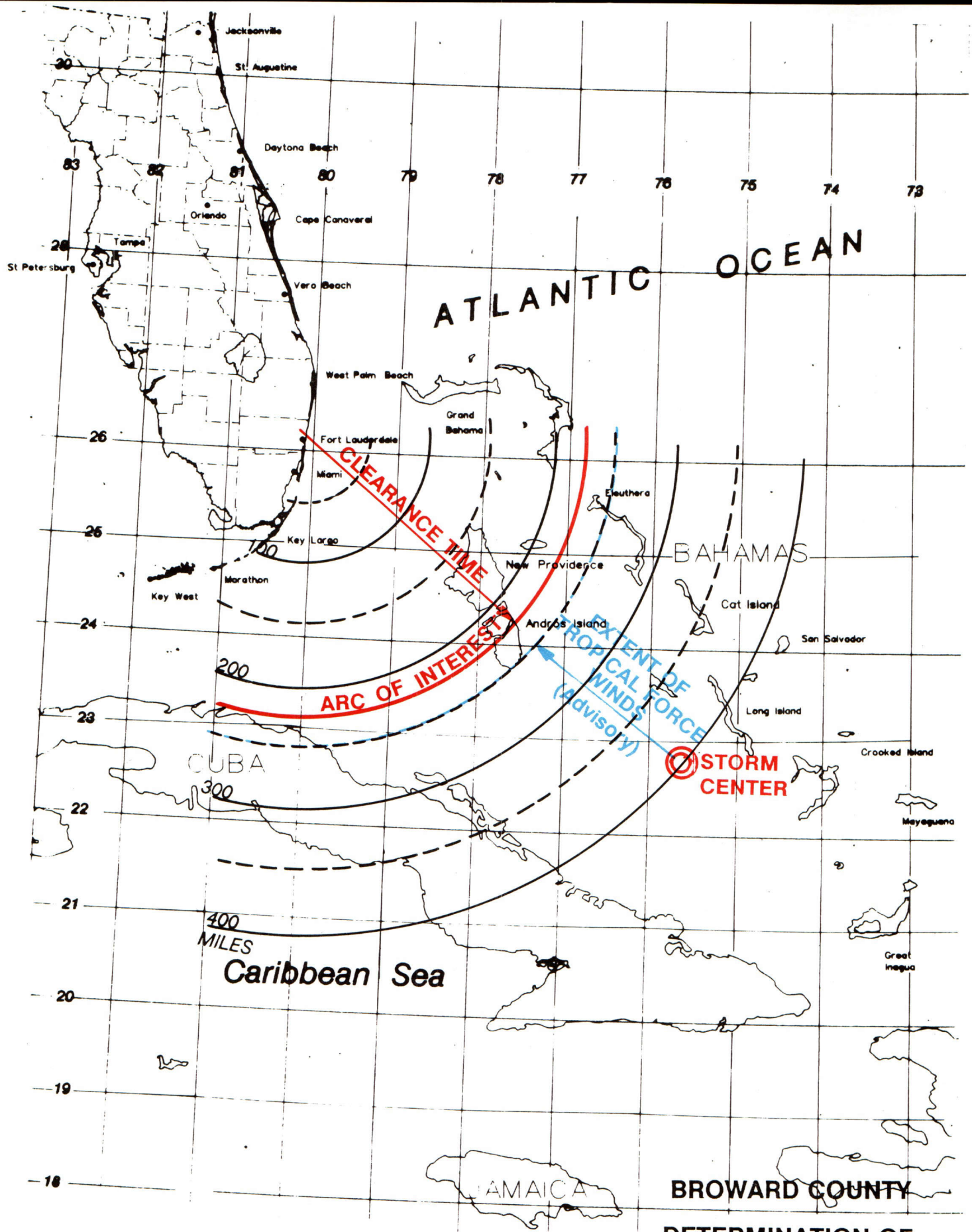
4. Determine how much time is available before tropical force winds reach the "Arc of interest".
   Example: 250 - 225 = 25 miles
   Storm moving 15 mph
   Answer: 1 hour and 40 minutes available (before evacuation order is given)

5. From advisory determine 12 hour forecast position of storm. Subtract from current storm center position in miles (in this example 400 miles) to determine how far storm is expected to move in 12 hours. Divide by 12 to determine new forecasted storm speed.

6. Utilizing forecasted storm speed go back and re-determine arc of interest. Continue process, if needed.

NOTE: Example numbers are in MPH and statue miles

Figure 7-2



BROWARD COUNTY

DETERMINATION OF TIME FRAMES AND CRITICAL DISTANCES

TABLE 7-1

DECISION ARC SET-UP
WITH NEWLY COMPUTED
CLEARANCE TIMES FROM
CURRENT STUDY
CATEGORY 1-2

Cat 1-2 Evacuee Response		Clearance times in hours for 2 tourist occupancy levels L Low	H High
R	Rapid	11 1/4	11 1/2
M	Medium	12 1/2	13
S	Slow	14 1/4	14 3/4

Storm Speed* Response	Decision Arc L	H	Storm Speed* Response	Decision Arc L	H
10-R	F	G	15-R	I	I
10-M	G	G	15-M	J	J
10-S	H	H	15-S	K	L
	L	H		L	H
20-R	L	L	25-R	O	O
20-M	M	M	25-M	P	Q
20-S	O	O	25-S	R	S

*Storm speeds are in knots

TABLE 7-1 (con't)

DECISION ARC SET-UP
WITH NEWLY COMPUTED
CLEARANCE TIMES FROM
CURRENT STUDY
CATEGORY 3

Cat 3	Evacuee Response	Clearance times in hours for 2 tourist occupancy levels L Low	H High
R	Rapid	16 1/4	16 1/2
M	Medium	17 1/2	18
S	Slow	19 1/4	19 3/4

Storm* Speed Response	Decision Arc L	H	Storm* Speed Response	Decision Arc L	H
10-R	I	I	15-R	M	M
10-M	I	I	15-M	N	N
10-S	J	J	15-S	O	O
	L	H		L	H
20-R	Q	Q	25-R	U	U
20-M	R	R	25-M	V	W
20-S	T	T	25-S	Y	Y

*Storm speeds are in knots

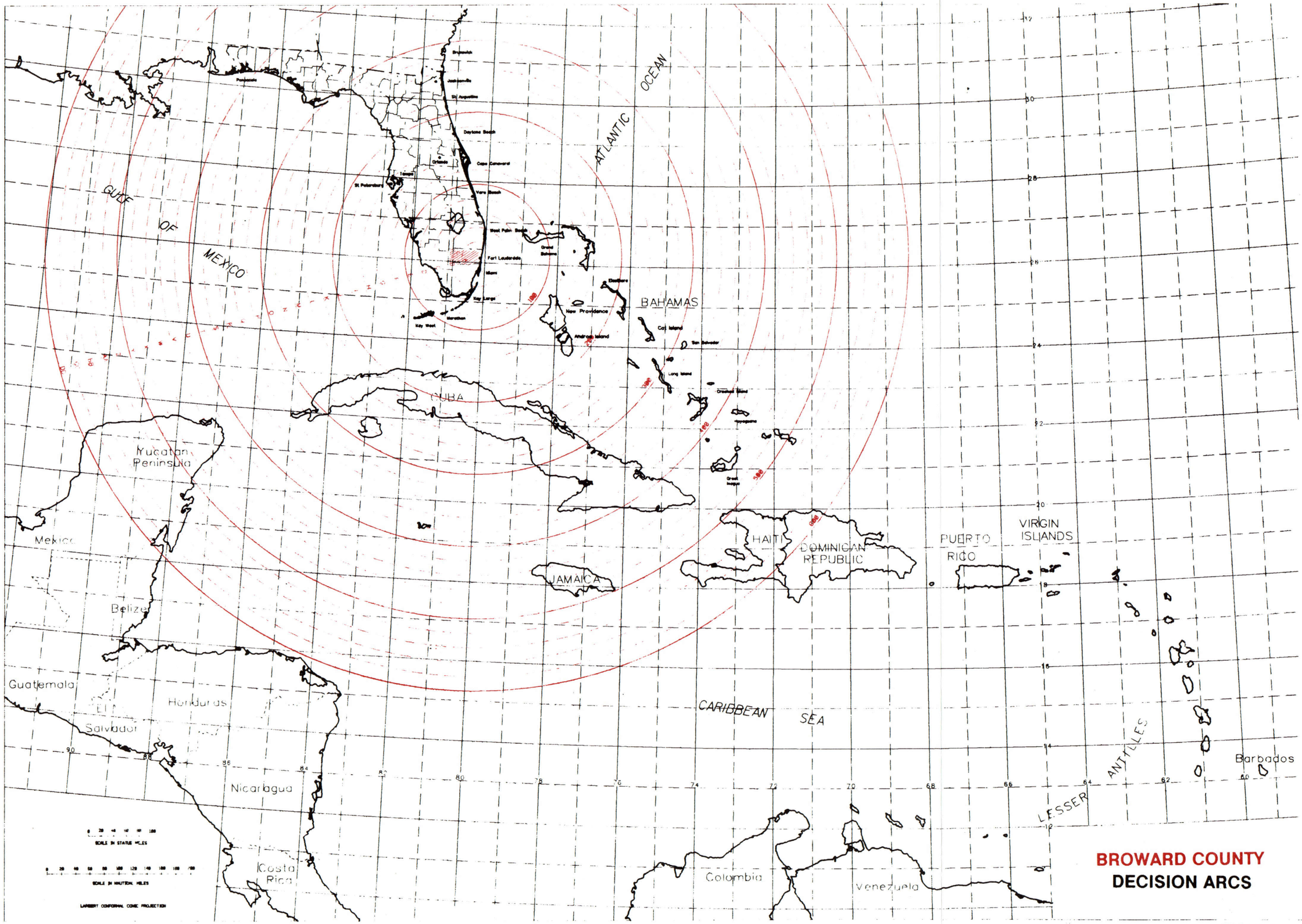
TABLE 7-1 (con't)

DECISION ARC SET-UP
WITH NEWLY COMPUTED
CLEARANCE TIMES FROM
CURRENT STUDY
CATEGORY 4-5

Cat 4-5	Evacuee Response	Clearance times in hours for 2 tourist occupancy levels L Low	H High
R	Rapid	21 1/2	22
M	Medium	23 1/4	24
S	Slow	25 3/4	26 1/2

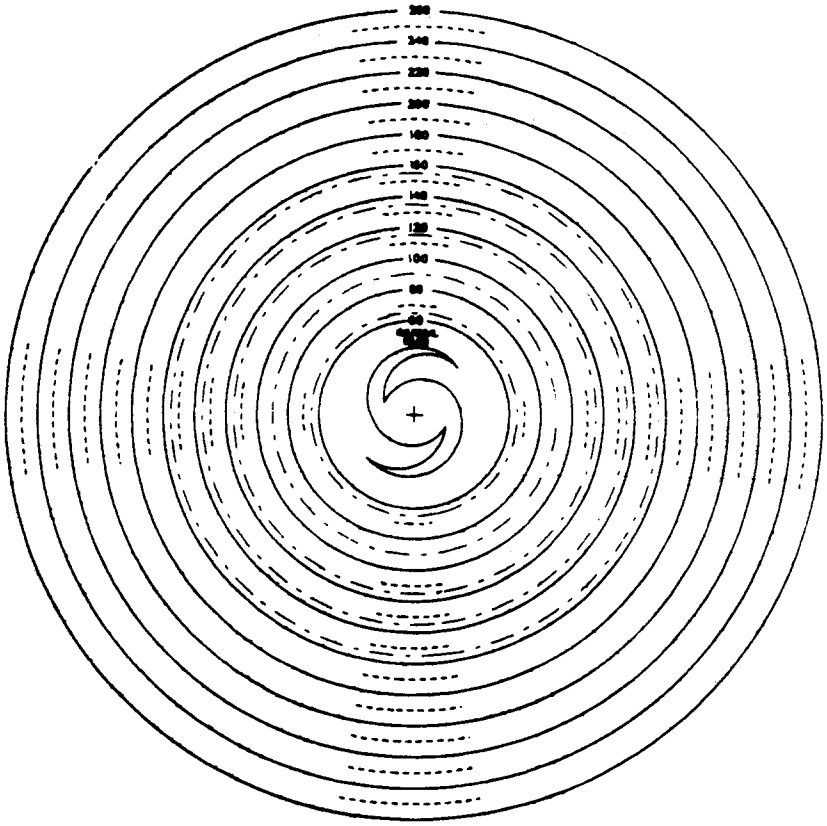
Storm* Speed Response	Decision Arc L	H	Storm* Speed Response	Decision Arc L	H
10-R	K	K	15-R	Q	Q
10-M	L	L	15-M	R	R
10-S	M	N	15-S	T	T
	L	H		L	H
20-R	V	V	25-R	AA	BB
20-M	X	X	25-M	DD	-
20-S	Z	AA	25-S	-	-

*Storm speeds are in knots



BROWARD COUNTY
DECISION ARCS

FIGURE 7-4



STORM PLOT OVERLAY

BROWARD COUNTY

FIGURE 7-5

CHAPTER EIGHT
RESPONSE AND STRATEGIES

GENERAL

Broward County's evacuation times (clearance times) are not excessive but they are greater than Dade County's time. Even with the large number of evacuees (see transportation chapter) the roadways allow a fairly reasonable evacuation response except for the very worst scenario. Because of the fairly reasonable times and the more normal storm approach, a fairly straight forward approach to the evacuation decision can be made. Maximum evacuation times in the 15-20 hour range would translate to an arc of interest in the 225 - 400 mile range for storms with forward speeds ranging between 15 and 20 mph (which is the normal speed in this area).

The evacuation decision thresholds for Broward County, then, relate fairly well to better defined probabilities from the NOAA marine advisories. Any large storm approaching through the "Bahama Boundary" that is still on target when the tropical force winds approach the 300 - 400 mile arc range becomes serious concern at that point. Every conceivable strategy should then be used to minimize the time needed to start and finish an evacuation. The evacuation should be staged such at a minimum that the following:

a. Tourists should leave the barrier islands as early as possible. All motels, hotels, campsites and RV parks should be closed.

b. Residents between the ocean and the intracoastal waterway should leave as early as possible.

c. An urgent appeal to evacuate must be made through the media and by public officials.

d. Residents adjacent to or near the intracoastal waterway and/or near the fingers and rivers off the waterway (particularly from Ft. Lauderdale south) should leave as early as possible.

e. Crucial that Navy and Coast Guard personnel commit to the evacuation (or to the decision to stay, if that be the case) very early.

f. Traffic control and vehicle assistance provisions must be available well in advance or when the storm is 400 miles out.

The foregoing basically would result in two evacuations for a large storm, one as early as possible and another sometime later. Meanwhile, the storm should be monitored to insure that selective movements of the remaining people further inland or on the northern and/or southern county perimeters can be made depending on 1) what the storm is doing and 2) on the strike probabilities. All of this assures, of course, that the minimum strategies outlined above are implemented (and agreed upon before hand). If during or near the end of the initial stage of evacuation the storm is still a large-intense storm and the probability of landfall in Broward County has not diminished appreciably, then, full scale mass evacuation of major portions of the county should be ordered.

ANNEX 1

HURRICANE EVACUATION DECISION WORKSHEET

HURREVAC COMPUTER MODEL

HURRICANE EVACUATION DECISION WORKSHEET

There are four (4) basic "tools" you will need in your evacuation decision process: (1) county Decision Arc Map; (2) county Decision Arc tables; (3) transparent STORM disk; (4) the NOAA National Weather Service (NWS) marine advisory.

1. From the NWS marine advisory, plot the last reported position of the hurricane eye on the county Decision Arc Map. Notate position with date/time. ZULU time (Greenwich mean time) used in the advisory should be converted to eastern daylight time by subtracting four (4) hours. Plot and notate the four forecast positions of the hurricane from the advisory.

2. From the marine advisory, note the largest radius of 34-knot winds, the forecast maximum sustained wind speed at landfall (to determine hurricane category), and the current forward speed.

3. Using the forecast maximum sustained wind speed in knots at landfall and the Saffir/Simpson Hurricane Scale, determine the category of the approaching hurricane. The Saffir/Simpson scale with maximum sustained wind speeds in knots is in a table at the end of this worksheet. Because of potential forecast and SLOSH model inaccuracies, it may be advisable to add one category to the forecast landfall intensity. With the category and the current forward speed, enter the county Decision Arc table and select the appropriate clearance time and corresponding Decision Arc. Mark this arc on the county Decision Arc Map.

4. Plot the largest radius of 34-knot winds onto the transparent STORM.

5. Using the center of the STORM as the hurricane eye, locate the STORM on the Decision Arc Map at the last reported hurricane position. Note if the radius of 34-knot winds falls within the Decision Arc. If so, the hurricane has passed the Decision Point (the point at which the radius of 34-knot winds crosses into the selected Decision Arc). In this case, measures should be taken to ensure a rapid public response in order for the evacuation to be completed prior to the arrival of sustained 34-knot winds (or consider advising no evacuation).

6. Determine the forecast forward speed of the hurricane by measuring the distance between the first and second forecast positions and dividing by 12. A speed faster than the current forward speed will indicate that the hurricane is forecast to accelerate, and, therefore, that less time will be available to the decision-maker. If forecast forward speed is greater than current, reenter the Decision Arc table and select the appropriate Decision Arc.

7. Move the STORM to the first forecast position. Again, note if the radius of 34-knot winds falls within the Decision Arc. If so, the recommendation to evacuate should be given before the hurricane eye reaches the first forecast position.

8. Determine as closely as possible how many hours remain before a decision must be made. Determine if sufficient time remains to evacuate after the next NWS marine advisory will be received. Use the probabilities table in the marine advisory to determine where an evacuation is likely to take place. Determine how

other counties would be affected by an evacuation of your county, and when they should be notified. Check inundation maps to determine where flooding may occur, and evacuation zone maps for zones that should evacuate.

9. At the Decision Point, check the probability table for your location. If probability is greater than 30 percent, strongly consider recommending evacuation. If the probability is less than 30 percent, you are encouraged to contact your Area Coordinator or State emergency operations center for recommendations.

10. Steps 1 through 9 should be repeated after each NWS advisory until a decision is made by the county.

Because information given in the marine advisory is in nautical miles and knots, the Decision Arc Maps and STORM have a nautical miles scale. When utilizing hurricane information from sources other than the marine advisory, care should be taken to ensure that distances are given in or converted to nautical miles and speeds to knots. Statute miles can be converted to nautical miles by dividing the statute miles value by 1.15. Similarly, miles per hour can be converted to knots by dividing the miles per hour value by 1.15.

SAFFIR/SIMPSON HURRICANE SCALE RANGES

Scale Number Category	Central Pressure Millibars	Central Pressure Inches	Winds (Mph)	Winds (Kts)	Damage
1	≥ 980	28.94	74-95	64-83	Minimal
2	965-979	28.50-28.91	96-110	84-96	Moderate
3	945-964	27.91-28.47	111-130	97-113	Extensive
4	920-944	27.17-27.88	131-155	114-135	Extreme
5	< 920	< 27.17	> 155	> 135	Catastrophic

HURREVAC

Some of the most important products developed as a part of the FEMA/Corps of Engineers hurricane studies and delivered to local state officials have been evacuation decision making tools. These tools have been decision arc maps and tables such as contained in this report, as well as computer software. Products such as these graphically tie together real-time storm characteristics with clearance time data. Their purpose is to give directors a means of retrieving technical information without having to dig through a report during an emergency. Evacuation decision tools suggest when an evacuation should begin relative to a specific hurricane, its associated wind field, forward speed, probabilities, forecast track, and intensity.

A computerized informational model has been developed which utilizes technical data contained in the study along with information contained in the marine and public advisories from the National Hurricane Center. The model, called HURREVAC, is a tool to assist local officials in making hurricane evacuation decisions. HURREVAC was adapted to Georgia and its data base and delivered to county officials just days before Hugo threatened the area.

After entry of Hurricane Center Marine Advisory data into the HURREVAC program the emergency manager can know within a few seconds, the implications of the latest Advisory for his community..such things as Gale Arrival time, Evacuation Decision time, Eye Arrival time, Evacuation Clearance time, extent of flooding from the Zone Map graphics, etc., all based on official data and Federal studies, and a quick idea of the Evacuation Scenario that could develop, based on historical evacuation patterns.

Using HURREVAC, a new Emergency Management official can quickly get "up to speed" on the complexities of the situation...a process which might have taken many months (or years) of experience to develop. HURREVAC can be used to run hypothetical hurricanes into the area as valuable training.

Following are the main features of the HURREVAC program:

QUICK DATA ENTRY - The Data Entry screen is designed to allow quick and easy entry to data from the NHC Marine Advisory. The program automatically handles non-standard Advisories such as Special and Intermediate Advisories, allowing you to update every 2 or 3 hours when the storm gets close.

RUN "WHAT IF" SCENARIOS - The program allows you to adjust the Storm intensity and track to quickly see the effect of unanticipated changes in those parameters on your area.

EVACUATION ZONES MAPS - Quickly bring up computer graphics showing the SLOSH generated flooding maps for your area, for this storm or any other Category of storm. Evacuation Zones and Flooding scenarios are highlighted. One can cycle through the maps using just the arrow keys on the keyboard...Up/Down arrows to access the next higher or lower Category map, Right/Left arrows to access maps for an adjacent area or county.

SHELTER DISPLAYS - See which shelters are available, their capacity and their vulnerability to storm surge, for each storm Category.

RESEARCH/TRAINING CAPABILITY - Run old Advisories or make up new storms to test Emergency Management actions and procedures. Computer will set the Date/Time for you and restore your original time upon exit.

The HURREVAC model is being provided all four counties in the Lower Southeast Florida study area.